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ABSTRACT

Four papers discuss both perceived and tested uses of communications satellites for amplifying access to information and for fostering networking among higher educational institutions around the world. Derived from the work of the Foundation for the International Exchange of Scientific and Cultural Information by Telecommunications (FISCIT), a guide by Martin Myerson (U.S.A.) focuses on uses of teleconferencing for scholarship. Demonstrations conducted by FISCIT are described, and four categories of teleconferencing options (audio teleconferencing, computer conferencing, computer networks and video teleconferencing) are discussed in terms of technical characteristics, equipment, functions, relative costs, and advantages and limitations. Shoichi Noguchi and Yoshiki Nemoto (Japan) recommend the development of a worldwide satellite network that would make information resources uniformly available to people in all countries, and they discuss both technical and conceptual aspects of such a system in light of experiments realized in different countries. A paper by Kyril B. Serafimov (Bulgaria) emphasizes the expansion of educational tasks brought about by space-oriented subjects and raises technical and economic questions and the issue of international cooperation. A concluding paper by Jose Luiz Braga (Brazil) ties together the preceding three and comments further on the relationship between national and international tasks, the effect of technological means on learning, and the production of software. (NRP)

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THE IMPACT OF SATELLITE TECHNOLOGY ON UNIVERSITY TEACHING AND RESEARCH

Research Document realized by

The Unesco-IAU Joint Steering Committee

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Shoichi NOGUCHI
Yoshiki NEMOTO
Kyril B. SERAFIMOV

The Impact of Satellite Technology on University Teaching and Research

Contents

Note by the Unesco Secretariat

Section 1

MEYERSON Martin: The Contribution of International Telelearning to University Teaching and Research: An Outline Guide for Users

Section II

NOGUCHI Shoichi and NEMOTO Yoshiki : The Impact of the Satellite Communication Networks on Research and Education

Section III

SERAFIMOV Kyril B. : The Impact of Satellite Technology on University Teaching and Research

Section IV

BRAGA Jose Luiz : Telecommunications for University Teaching and Research (An Approach to some educational problems).

NOTE BY THE UNESCO SECRETARIAT

In 1960, the Joint Unesco-International Association of Universities Research Programme in Higher Education was established and began its work.

Its purpose is to carry out, with the advantages of joint sponsorship, studies on aspects of the organization, structure and functioning of higher educational institutions and systems in the changing conditions of the present day. These have included Access to Higher Education, the Role of Universities in the Development of Countries in Southeast Asia, University Co-operation in Africa, Change and Innovation in Latin American Universities and, more recently, Universities and Environmental Education. Publications resulting from the Programme are issued by Unesco on behalf of the two organizations.

The present study on the impact of satellite technology on university teaching and research was undertaken by eminent scholars in four countries:

- Martin Meyerson (U.S.A.), President Emeritus, University of Pennsylvania
- Shoichi Noguchi and Yoshiki Nemoto (Japan), Tohoku University, Sendai
- Kyril B. Serafimov (Bulgaria), Member of the Bulgarian Academy of Sciences
- José Luiz Braga (Brazil), Professor of Social Communications, Universidade Federal da Paraiba

While the Bulgarian paper addresses the topic chosen directly, those from Japan and the United States provide interesting insights into certain aspects which merit close attention - namely, the impact of satellite communication networks and the contribution of telelearning to university teaching and research. The Brazilian paper provides comments on the other three documents and suggests an approach to some educational problems involved.

As the academic community prepares to face the 21st century, the presence and impact of advanced technology is a widely accepted reality which facilitates the teaching and learning process and, at the same time, allows scholars worldwide to communicate in order to share their investigations and findings. Thus, this technology has already made a significant contribution to the promotion of international co-operation in the field of higher education.

It is hoped that the study will provide an opportunity to examine this important question in relation to the traditional functions of the university. At the same time, academics are encouraged to undertake further research and experimentation in order to achieve still more impressive results, thereby extending the frontiers of knowledge and preparing to meet the challenges of our future society.

Section 1

Martin MEYERSON

The Contribution of International Telelearning to University Teaching and Research: An Outline Guide for Users

THE CONTRIBUTION OF INTERNATIONAL TELELEARNING TO UNIVERSITY TEACHING AND RESEARCH

AN OUTLINE GUIDE FOR USERS

MARTIN MEYERSON*

TABLE OF CONTENTS

I. Introduction: Teleconferencing ---------- 1

II. Demonstrations

A. Economic Policy Teleconferences ---------- 7

B. Visiting Statesmen Teleconference (Pre-recorded Video and Multiple Side Audio Linkage) ---------- 11

C. HIPAS Laboratory - High Power Active Stimulation of the Auroral Plasma (Slow-Scan Video-Audio Teleconference) ---------- 13

D. Computer Graphics Experiment ---------- 16

III. Teleconferencing Options

A. Audio Teleconferencing ---------- 18

1. Audio Applications in Education ---------- 25

2. Audiographics ---------- 27

a) Facsimile ---------- 29

b) Electronic Blackboards ---------- 32

c) Remote Control Projectors ---------- 33

d) Personal Computer-based Graphics Generation ---------- 34

3. Videotext Graphics ---------- 35

4. Telewriters ---------- 37

B. Computer Conferencing ---------- 38

C. Computer Networks ---------- 42

1. Cost Considerations ---------- 44

2. Sample Applications ---------- 45

3. Implications for Developing Countries --------- 45

D. Video Teleconferencing ---------- 46

1. Slow-scan Video ---------- 47

2. Full-motion ---------- 52

3. The Technology ---------- 54

4. Videoconferencing Rooms ---------- 59

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Chairman, Governors' Executive Committee, Foundation for the International Exchange of Scientific and Cultural Information by Telecommunications (FISCIT)

IV. Satellite Systems

A. INTELSAT ---------- 65

B. Applications ---------- 70

V. Conclusion ---------- 78

The Contribution of International Telelearning to University Teaching and Research

An Outline Guide for Users

Knowledge is an increasingly vital resource. It is vital not only for intrinsically valuable learning, but even more for learning as a requisite for economic development and for health and other social and cultural advances as well. The discovery, processing and dissemination of knowledge or information take place in various forms.

This guide is directed to one set of those forms: cross-national teleconferencing as an adjunct to and sometimes a substitute for other kinds of human communication in higher education. It is an introduction to the functions, uses (including limitations) and facilities and equipment for teleconferencing for scholarship and learning. It emphasizes relatively low cost options, inevitably a concern of developing and also prosperous countries. The hardware examples cited are frequently from

the United States, because much of the present equipment is from there, but that situation is changing.

Most of this guide derives from the work of FISCIT, a consortium of research universities in Europe and North America. (Its membership may extend across the Pacific in the near future.)

Teleconferencing is more extensive and considerably less expensive than it was a decade ago. A few years hence, it should be a most important and economical asset to universities everywhere for inter-campus domestic use and, as dealt with in this guide, for international sharing among centers of higher education and research. Unfortunately, just as computers which were originated in universities were employed far more fully for many years by other types of organizations and institutions, so we have been facing a similar trajectory in telecommunications. That condition for international teleconferencing in the world of universities ought to be altered.

Teleconferencing is group communication through any electronic means. There are several main varieties of teleconferenicng covering 1) voice, 2) video, 3) graphics and 4) data (primarily by computer). Though each form can be used separately, and it is often appropriate to do so, our emphasis is on links or

networks covering all four of the above. Despite that emphasis -- but also to help explain it -- we shall also deal with each variety of teleconferencing.

We shall at the start make a simple distinction. If all participants are present simultaneously, regardless of time zone or location, the teleconference is termed "synchronous." On the other hand, if information is recorded and stored, and the participants can check into the conference when they wish, it is an "asynchronous" or "store and forward" conference, as with computers. The former mode is related to real time, a concept to which we shall return.

We shall use an example of one embryo effort of international multi-form teleconferencing. FISCIT is the abbreviation for the Foundation for the International Exchange of Scientific and Cultural Information by Telecommunications (a translation from the German and the French.) The recent experience of that consortium of research universities may provide insights into opportunities through teleconferencing for the advancement of cross-national scholarship and education. The Foundation was chartered in 1982 with a base at the Eidgenössische Technische Hochschule (the Federal Institute of Technology) in Zurich. In addition to Switzerland, its founding members were drawn from France, Germany, Great Britain and the United States. In 1985, it was incorporated in the United States

as well, an arrangement confirmed by its Board of Governors at a meeting in London in Mid-January, 1986. At that time the main office was established at the University of Pennsylvania and the chairman of the executive committee was also selected as the first president.

The main purpose of FISCIT is to further knowledge and understanding through additional international linkages. The traditional exchanges among advanced scholars, professionals, teachers and university students have been through travel (and, of course, publications). Yet the increasing costs -- and not only monetary costs -- of human movement across long geographic distances limit the number and effectiveness of such interexchanges. Also, eminent senior research scholars are often reluctant to accept the travel time demands upon them for the many conferences, seminars, workshops, and lectures to which they are invited. Furthermore, given budget restraints at universities, the opportunities for such travel are offered less frequently now to young academics.

Fortunately, substitutes for and supplements to travel may be achieved through new and evolving technologies of communication. These technologies, transversing national boundaries, include audio connections, analog and compressed digital full motion video (which provide maximum interaction in real time), electronic

blackboards and tablets, slow scan video links for transmission of images of faces, slides, diagrams and similar materials and their facsimile reproduction -- and, of course, computers for both data and graphics.

During the short history of FISCIT, teleconferencing services have become more cost effective. (The recent destruction of the shuttle, Challenger, may set back the downward slope of that cost curve.) In Europe, Japan and in the United States and elsewhere, various groups have been increasingly discovering and creating the demand for means of communications which conserve travel time and resources. International optical fiber communications systems scheduled for 1988 and the years beyond will be an adjunct to satellites and their transponders and will reduce transmission costs.

The international scholarly community can benefit from these new technological means of communication through bi-lateral links between two locations and simultaneous linkages among institutions in several countries. The following examples illustrate potential applications:

-- Seminars of experts from various institutions of higher learning who could both hear and see each other through satellite -- and terrestrial -- video and audio connections as well as transmit data and graphic materials.

-- Computerized data bases could be exchanged and the data adjusted as new assumptions are programmed, arising from the interexchange of views and knowledge of participants.

-- Teaching demonstrations of complex techniques, such as advanced medical or scientific or engineering processes, could be presented to specialized audiences who could have the chance for at-the-moment questions and answers.

-- Lectures, with or without visual materials, could be transmitted to many locations (either in real time or time delayed), permitting diversification and enrichment of curricula and also permitting professors attached to one university to be accessible to students and faculty at other universities. Distinguished teachers, scarce resources as they are, could thus, to some extent, be shared.

FISCIT demonstrations using current telecommunications technologies described below have linked various institutions. The contents were central to the demonstrations, which were also planned to detect what kinds of preparations were most useful, what kinds of problems might arise, and what kinds of benefits could result. Brief versions of a few demonstrations follow.

A. Economic Policy Teleconferences

The substantive purpose of these teleconferences, the first of which took place in April and the second scheduled for May, 1986, was to review key issues, the implications of which would be discussed by the leaders of Japan, Canada, the United States, the United Kingdom, France, the Federal Republic of Germany and Italy during the economic summit meetings. The methodological purpose was to test the costs and efficacy of current telecommunications technologies in providing linkages among scholars and professionals.

Several weeks before the 1984 London economic summit meeting and the FISCIT teleconference, a conference with nearly eighty participants was held at the United Nations headquarters in New York City. It examined a set of economic forecasts relevant to the London summit. Those who planned the U.N. meeting recommended that a subsequent meeting be arranged after the forecasters reviewed their estimates in which analyses of available policy options that lie ahead for individual countries and their economic implications would be reviewed.

With the concurrence of its executive committee, FISCIT agreed to organize the subequent meeting as a teleseminar. On the recommendation of the U.N. telecommunications staff, Satellite Business Systems (SBS) was engaged for technical services.

SBS had just obtained clearance from the U.S. Federal Communications Commission for digital video transmission across the Atlantic.

The three and a half hour conference took place simultaneously in McLean, Virginia, near Washington, D.C. (the location of the SBS headquarters); in Los Angeles (at the Bank of America studio on behalf of the University of California; in London (at the Confravision studio of British Telecom International) and in Geneva (at the United Nations offices). The participants included senior economists of the Bank of America, The Federal Reserve Bank, the U.S. Department of State, the United Nations, OECD, INSEE, Bank of Japan, the Swiss banking community, the University of Bologna, the Bank of Italy, the University of Brussels, the University of Toronto, the London School of Economics, Stanford University, and faculty from FISCIT's member institutions.

In advance of the conference, Dr. Peter Pauly, formerly of Hamburg University and a colleague of Nobel Laureate Lawrence R. Klein (of the University of Pennsylvania), who moderated the 1984 pre-summit meeting and will moderate the 1986 post-summit one, prepared and forwarded to the participants a summary of world economic activity in part derived from the meeting at the U.N.

A baseline of the LINK model of the world economy was used. The LINK model

has complete global coverage, consisting of statistical models for all OECD countries (Canada, the United States, Japan, Australia, New Zealand, the EEC countries and other Western European economies) and eight centrally planned economies. The developing countries (oil-producing and non oil-producing) are represented by five regional models. The LINK model has 13,000 non-linear equations plus linkage modules which reflect bilateral trade and prices as well as currency exchange rates.

During the conference, policy options available to the summit countries were reviewed. The probable response of each government (and of marketplaces) was derived from four computer terminals located at McLean and Los Angeles. These terminals were connected to the Rittenhouse Laboratory computer facility in Philadelphia through 1200 or 2400 baud modems using land lines. During the teleseminar, once the policy recommendations were postulated, economic simulations were run for the years 1985 - 1987 on a quarterly basis. It took about fifty minutes from the time the recommendations were formulated until the results were computed and the tables presented via TYMNET to London. The participants in McLean and in Los Angeles had the data immediately available on the terminals located there. London and Geneva suffered because of inappropriate modems at

BTI (Geneva was hooked into BTI) to bridge the incompatibility between the American and the European systems. To avoid this problem, we could have made fuller use of the computer network systems of TYMNET or TELENET across the Atlantic.

The color video connecting SBS in McLean and BTI in London was excellent. For this connection a 1.544 Mbps digital link was used.

(N.B. In the final report, a brief version of the May 7 post-summit teleconference, initiated by Kokusai Denshin Denwa in Japan, will be included.)

B. Visiting Statesman Teleconference

(Pre-recorded Video and Multiple Side Audio Linkage)

The substantive purpose of this demonstration was to give students of political science and government at FISCIT member institutions the opportunity to discuss the responsibilities, possibilities and limitations of public leadership with a distinguished statesman. The technical purpose of the demonstration was to test a two-way, transatlantic audio linkage among several universities, preceded by a pre-recorded video interview as a framework for the questions and answers.

A few days prior to the teleconference, the former Prime Minister of England, James Callaghan, was interviewed by Philip Windsor of the faculty of the London School of Economics (LSE). The interview was videotaped in London and duplicate tapes sent to the participating universities to be viewed just prior to the audio-conference.

Dean Leonard Freedman of the University of California, Los Angeles, and formerly of LSE, moderated the teleconference. Following Dean Freedman's introduction, Mr. Callaghan answered two rounds of questions from students at each university. The presiding faculty member at each location then asked a concluding

question. Mr. Callaghan participated in the teleconference from LSE.

The participants would have preferred a live video connection, but agreed that the general discussion did not require it. The students' questions (a queuing system had been set up) were concise and well informed while Mr. Callaghan's responses to both sides of the Atlantic were informative and lively. The teleconference demonstrated how this communications technology could be used in the classroom with valuable results.

C. HIPAS Laboratory - High Power Active Stimulation of the Auroral Plasma (Slow-Scan Video-Audio Teleconference)

This teleconference connected the HIPAS Laboratory of the University of California, Los Angeles, with its field laboratory in Fairbanks, Alaska. The original substantive purpose of this teleconference was threefold: to allow the director of HIPAS, Professor Alfred Wong, to meet with Fairbanks staff from his UCLA office; to enable UCLA engineers to diagnose equipment problems at the Fairbanks lab; and to permit UCLA faculty and students to monitor experiments in progress in Alaska. The technical purpose of the demonstration was to use slow-scan video, specifically the Photophone of the Image Data Corporation, a portable unit which combines monitor, digital electronics, modem and camera.

The arrangements for the teleconference included the placement of a Photophone at each of the two sites connected by a standard voice-grade long distance telephone circuit. Since the Photophone can only send and receive black-and-white video still pictures, an additional voice circuit to be connected to speaker phones at each end was provided for the audio portion. In addition, both Photophones were connected to large screen television monitors and a video recording was made of the audio and video received at UCLA.

A testing period had been scheduled for the afternoon before the conference. The connection would be made between the Plasma Physics conference room on the UCLA campus and a conference area at the Fairbanks lab. The latter was not equipped with telephone lines, however, and their installation was not completed in time for the testing period. Furthermore, experiments which were being run in the Fairbanks lab interfered with the Photophone testing.

The teleconference which took place the next morning had several technical difficulties, all of which originated at the Alaskan site. Although the telephone lines were in place before the conference began, they had been improperly installed and thus the transmission quality was poor. While the long distance circuits were established from UCLA by dialing through the regular university telephone exchange (which allowed the call to be made along the least expensive route), the Fairbanks lab was not able to switch the incoming call to the proper extension which delayed the conference by about thirty minutes. Participants had trouble hearing one another which inhibited spontaneity and still pictures of a person talking (already ten seconds old by the time they were displayed at the receiving end) added little to the meeting's content. Even though Tel-Spec (the local distributor of the Photophone) had a technical representative at each site, the equipment

itself could not be properly utilized during the conference. A logistical coordinator, however, would have increased the probability that the Photophone was utilized to the best of its capability. UCLA colleagues concluded that slow-scan video is still an attractive means of communication for meetings in which the exchange of visual material is the primary purpose of the teleconference. The relatively low cost, portability and simple installation (assuming telephone lines already exist) of the equipment used made it a valuable option.

D. Computer Graphics Experiment

Recognizing that future research and development in computer graphics should lead to superior image processing and pattern recognition in physics, medical diagnosis and other scientific applications, several FISCIT members have conducted tests in exchanging pictorial data through high speed digital data links. Colleagues at the Technische Hochschule (ETH) Zurich and the University of Hamburg have been successful in exchanging pictorial data through such links, but the attempt to include The Johns Hopkins University in the experiment failed technically.

A significant factor in planning this test transmission of ophthalmology data was the offer by RCA and the Swiss PTT to allow FISCIT to conduct experiments on a satellite channel recently acquired by a semi-private organization, Radio Schweiz AG. RCA permitted that FISCIT would be free to use this 64 kbit/sec channel on INTELSAT V until a commercial client was found. Since Johns Hopkins University already had access to high speed computer interfaces required to use this channel, and ETH Zurich could obtain an interface on a trial basis from the Digital Equipment Corporation (DEC), the demonstration would link these two institutions with the hope that the Applied Physics Laboratory at Johns Hopkins could also join.

RCA found a commercial client much sooner that had been anticipated which

considerably shortened the time available. ETH Zurich was able to establish a digital data connection between the Institute of Communication Technology and the Swiss satellite gateway in Leuk. The connection with Hopkins could not be established, and thus the project was modified to link only the RCA Technical Center in New Jersey and ETH Zurich.

The methodological purpose was to experiment with the use of the satellite channel and to observe the transmission quality of the pictorial data used. Fixed synthetic data patterns were first generated at ETH Zurich on a DMR-11 interface provided by DEC Switzerland and transmitted to the INTELSAT V channel. They were then transmitted to the RCA Technical Center which then bounced the patterns back to Switzerland to be received on the VAX computer at ETH and checked for errors. Although the link between ETH and the Swiss gateway worked without problems, the data synchronization was lost on the full path. In addition, the transatlantic connection was not of sufficient quality to maintain transmission of image data routinely. The technology did not operate as well as had been anticipated.

Upcoming improvements in packet switching services are expected to provide high quality transmission and often at lower cost. The Swiss PTT's TELEPAC is one such service.

Teleconferencing Options

While FISCIT was conducting such demonstrations, we also were evaluating the teleconferencing options that were available. A review of some of these follows. We should report that the frequent references to American products ought not to be considered as recommendations of United States equipment, but is rather a reflection of current availability. To simplify cost comparisons, dollar figures are used predominantly.

Audio Teleconferencing

Audio teleconferencing is voice-only interaction among individuals located at two or more sites connected by a telephone system. The communication is established by audio conferencing equipment and public -- or private -- telephone transmission channels. Audio is the backbone of teleconferencing media.

The functions of audio teleconferencing are :

- To deliver or exchange information or views in which visual communication is either not an important factor or in which material may be sent to the participating sites in advance of the teleconference.
- To provide access to knowledge about educational, health, economic and community services which are not available at one of the user sites.

The advantages of this communication medium are :

- Low cost of communication charges.
- Relatively inexpensive user equipment.
- Extensive availability of networks worldwide.
- Flexibility in linking locations.
- Familiar technology.
- Dial-up or relatively short notice required to arrange a teleconference.

The constraints in audioteleconferencing include :

- Non-verbal communications impossible.
- Impediments in sending visual information in advance of the meeting.
- Different time zones.
- Technical difficulties such as static on channels if they are not of reasonable high quality; interruption of total loss of transmission.
- Limited telephone service in certain parts of the world.

Transmission options are varied :

- Public telephone networks.
- Leased lines (also called dedicated lines).
- Voice-grade channels.
- Satellites.

The term "leased lines " refers to situations in which a teleconferencing network leases for a fixed sum telephone lines which are then used to link only members of the network.

"Voice-grade" refers to a standard telephone line which was designed to carry frequencies below 3,400 Hertz. "Hertz" (abbreviated as Hz) is a measure of frequency. (1H = 1 cycle per second.) Telephone frequencies of about 4,000 Hertz (4 KHz) are necessary for voice transmission. Since only a relatively small portion of a communications channel is used the mode is referred to as "narrowband" transmission. In contrast, "broadband" or "wideband" refers to a greater channel capacity. For the purpose of comparison, telephone frequencies of about 4,000 Hertz (4 KHz) are necessary for voice transmission -- television needs a bandwidth of about 4,500,000 (4,5 MHz) to transmit moving images. Since in broadband transmission more channel capacity is needed, obviously the cost of broadband transmission is higher than that of narrowband transmission.

A "satellite" is a "repeater" which orbits the earth every 24 hours. "Repeater" is a device which enables currents received over one circuit to be

automatically repeated in another circuit or circuits. (Satellite systems will be discussed later.)

Audio System Options

An audio teleconference may be initiated with a conference call placed from one of the participating sites or by an operator. In large conferences the use of a bridge or a bridging service is necessary. A "bridge" is a device which enables various telephone lines to be connected to ensure transmission balance and a good quality of the audio communication.

The bridging device may be "simplex" or "duplex." Simplex bridges permit only one voice to be heard on the system at one time. There is a certain time delay before another speaker can begin to talk. Duplex bridging provides audio communication without delays.

The cost of bridges varies, depending mainly on the number of ports that can be interconnected. For example, A T & T's Quorum bridge, linking 20 ports, costs about $40,000. Darome markets a widely used bridge for $46,000. Additional ports can be added by tandem bridging systems at additional cost. Generally, an operator has to be engaged to monitor lines for problems and to provide other coordinating tasks.

For lower volume users, it may be more economical to employ bridging services. For example, A T & T's Alliance Teleconferencing Service has been providing international bridging services since April, 1985. This service includes an option to initiate the conference outside of the United States, but the initial call has to be made to an A T & T bridge in the United States. To originate the call, touch-tone telephone equipment must be used but other sites can be added by using other telephone equipment. The

current cost is 25¢ a minute per leg (a connection between two locations) in addition to regular long distance telephone charges. A T & T's Alliance 2000 service can be added to connect graphic equipment, such as interactive writing devices and freeze-frame video systems. If both voice and graphics are transmitted the cost of bridging is 50¢ per minute per leg. A T & T also supplies dedicated audio service up to 59 ports for a fixed monthly fee of $6,600.

Darome, Inc. is another U. S. commercial bridging service. Its current charge is $10 for 30 minutes for audio service and $20 for 30 minutes of photo-bridging.

Connex International, Inc. in addition to providing bridging services in the U.S. connects sites in various countries through its WorldCall service. The company also provides access to language translators and records conferences.

Audio Equipment

Audio equipment varies from simple loudspeaker adjuncts for ordinary telephone handsets to sophisticated integrated audio conferencing systems with multiple microphones and speakers. The latter allow many people gathered in one room to hear and be heard.

The applications are of a primary concern when choosing the audio equipment. Thus, a decision based on whether the user needs a portable system which can be plugged in wherever needed, or whether a permanently installed system is a better option must be carefully made. Another consideration is the design of the microphones :

-- Open microphone systems transmit continuously, and thus can pick up sound from all directions. The acoustical treatment of the conference room must be excellent in order to prevent interference from background noises. Consequently, the user must determine whether the ease of the use of this equipment is worth the additional cost of acoustical treatment.

-- Voice-switched microphone systems have a microphone which is closed until a sound of sufficient amplitude turns it on by moving it into a transmit position. Excess noise can trigger transmission; in addition, it should be noted that only one person can talk at a time and it can be difficult to interrupt.

-- Press-to-talk microphones are activated by a bar or a button depressed by the user. As soon as the system is activated background noises are eliminated.

Another important consideration is whether the audio system is meant to be automatic or operated by a technician.

The following list of sample suppliers is included only for the purpose of illustration.

Audio desk and tabletop terminal equipment:

A T & T Information Systems Quorum Portable Teleconference phone $ 1,100
Monthly lease $ 44

Quorum Teleconference Microphone and Speaker $ 1,150
(audio within 12' radius of microphone)
Monthly lease $ 44

Darome Model 610 Convener (portable)	$ 610
Darome recommends more sophisticated systems for larger groups, such as Darome 630 Convener (a full-duplex device which means there is no switching back and forth between microphone and speaker.	$1,200
Philips Conference System CCS 300 (1 microphone; distance of audio 6 - 18').	$1,500

Integrated audio systems must be permanently installed in a teleconferencing facility. In the United States, Shure Teleconferencing Systems supplies ST - 6000 Audio system for about $ 9,000.

A T & T Information Systems also offers an integrated audio conferencing system for about $ 6,300.

Other U. S. vendors include Teleconferencing Systems International, Inc. and Vidicom ("The Delegate" system includes echo cancellers for satellite circuits and telephone bridging options).

(N.B. Information on other European and Asian suppliers will be added.)

Audio Applications in Education

Interactive audio teleconferencing is an excellent medium for meeting certain educational needs of long distance learners. Used in Australia, Canada and elsewhere, it has given an opportunity to students in rural areas or at campuses located away from a major campus, to obtain introductory or continuing education courses at low cost to the institution. Improvements in bridging services have led to growth in applications.

In the United States, among the major users of this medium has been the University of Wisconsin - Extension.

The Learn Alaska Network (LAN) has one of the largest audio conferencing systems in the world. The substantive part of the programs is coordinated by the University of Alaska and the Alaska State Department of Education. LAN has conducted successful telelearning programs ranging from those for pre-school children to university credit courses to those for the aged.

The University of Wales College of Medicine in the United Kingdom developed in recent years a tutorial audio (enhanced by visual materials) program for its medical students located at separated locations. The system has alleviated the problem of overcrowded classrooms and also it has enabled students at district general hospitals to continue interactions with the major teaching center. The British Telecom's Telspec conference bridge has been used by the network.

Canada's Alberta Hospital Association established in 1984 an audio network which links almost one hundred hospitals in educational and administrative activities. Darome bridges are used in this network.

Audio, enhanced by visual materials, has great potential in those parts of the world that for historical and political reasons have not been able to share the technological advances of our century. For example, the Ocean University of Indonesia, using Indonesia's PALAPA satellite system, links about thirteen campuses over 2,500 miles of ocean in an important telelearning endeavor.

The United States Agency for International Development (USAID) has collaborated with Peru's national telecommunications authority, ENTEL, to test the suitability of satellite technology for educational and health service programs. With very high frequency (VHF) interconnections, three earth stations and INTELSAT V Global Beam, ENTEL has been able to provide community telephone and audioconferencing service to remote villages. Local teachers were able to participate in training programs originated in Lima; health care and instruction for it have been improved in regional hospitals because of the sharing of transnational technical expertise and resources.

In the Caribbean, audio technology also contributed to learning. Thus, a project has been underway in which the three main campuses of the University of West Indies (Jamaica, Barbados and Trinidad) are linked with centers on Santa Lucia, Antigua and Dominica. INTELSAT provided the link between Jamaica and Barbados, terrestrial lines were used for the other locations. The network has provided courses in pedagogy, health care and agriculture. Tutorial sessions have also been available to university students.

Audiographics

Audiographic devices augment the effectiveness of voice-only interactions among individuals or groups located at separate sites.

The term "audiographics" refers to transmissions of hand-written or printed material over narrowband telecommunications channels, such as telephone lines or a radio subcarrier. At times this mode of communication is also called "audio plus" or "enhanced audio."

The functions of audiographics in teleconferencing are :

- To provide complementary visual information.
- To meet "ad hoc" demands for visual support during an audio teleconference, such as displays of financial charts, printed documents, certain types of photography, scientific drawings, maps and library data.
- To illustrate in real-time at multiple sites graphic changes and (or) modifications of printed documents as they are discussed.

The advantages of enhancing voice-only communication by the use of audiographic devices are numerous. Among them are:

- Low cost of transmission over voice-grade telephones.
- Visual materials do not have to be mailed in advance of the telemeeting.
- Easy access to audiographics facilities in certain countries, due to availability of extensive networks, such as those in France.

Among the constraints to the growth of the audiographics medium are:

- The electronic devices are more expensive than in voice-only teleconferencing.
- Equipment is often more difficult to use, and thus an operator may have to be engaged or training provided.
- In some countries, the user has to own the equipment because only the bridging portion is offered by services.
- Resolution may be too low to illustrate all the necessary data.
- Limited to visuals as the showing of participants is not possible with this medium.
- Three-dimensional visuals are difficult to transmit because of the limited resolution over voice-grade telephone lines.

The major categories of audiographic devices include:

- Facsimile (also called "fax").
- Electronic writing devices, such as telewriters, tablet systems and electronic blackboard.
- Remote control projectors.
- Personal Computer (PC)-based graphics.
- Videotext graphics.

Facsimile

Facsimile is similar to television in that an image is scanned by an electronic device and then sent to a receiving site over telephone lines or radio subcarrier. At the receiving site the image is recreated on paper rather than on a television monitor. The speed of transmission depends on the bandwidth of the communications channel used.

The advantages of this mode of exchange of documents are:

- Availability of a permanent record on paper.
- Flexibility in sending many kinds of illustrations and texts in various languages.
- No keyboarding is necessary as the "fax" operation resembles an operation of a photocopy machine.

Standardization makes this device an important and versatile tool for international meetings.

The standards established by the Consultative Committee on International Telegraph and Telephone (CCITT) of the International Telecommunications Union fall into three groups:

Group I : a page, optically scanned, is transmitted in 4 or 6 minutes via analog signals over telephone voice-grade lines.

Group II : a page, analog scanned, is transmitted in 2 or 3 minutes via analog signals.

Group III : a page is transmitted in less than one minute digitally over voice-grade telephone lines.

Group IV : standards for the most rapid transmission have not been established as yet but are expected to be in the near future.

The applications determine the choice of equipment. If the equipment is not used often the speed of transmission is not as important as in applications that require frequent exchanges of documents. The compatibility of equipment at the originating and receiving site is necessary. Also, the operation may need a skilled operator. Another factor that must be taken into consideration is the location of the equipment as it often cannot be used during the actual teleconference because of the noise and the heat it generates.

Most devices sell for about $3,000, U.S. For example, PANAFAX, a subsidiary of Matsushita, offers model PX-200 for $2,900. It services the equipment in addition to providing training in the use of the equipment. A mass memory option enables the user to have a record of up to 40 letter size documents which can be transmitted at a preselected time whenever they are needed. The line connection may be a public switched telephone network, or a 2-wire leased line.

Equipment for transmission of high resolution graphics (2,200 x 1,700 pixels) over high speed lines is available in the U.S. from Teleconferencing Systems, Inc. The cost of its model, "Hiret," is $50,000.

A potential user may also engage the services of MIC Telecommunications. This company offers an international facsimile service from five facsimile centers, located in New York City, Washington, D.C., San Francisco, Miami and New Orleans. RCA Global Communications also provides "fax" services.

Electronic Blackboards

In a typical application of an electronic blackboard (in a conference, or a lecture, for example), the presenter writes on a space, size 51"x 65," which resembles an ordinary blackboard. The information written by the presenter is picked up by sensors which are located behind the board, then converted into audio tones and transmitted over telecommunications channels, usually telephone lines, to participating sites. The information received at the sites is displayed on a TV monitor as the presenter writes (or erases) at the originating site.

Among the advantages are:

- Instantaneous distribution of information over narrowband channels.
- No need for specially trained operator.
- Easy recording and reproduction of conference material.
- Clarity of the visual presentation.

In the U.S., A T & T's model Gemini has been used extensively in educational applications to add a visual dimension to audio interactions.

The Nippon Electric Company (NEC) has been marketing electronic writing board systems containing a built-in floppy disk drive which makes it possible to record and playback. The equipment can be adjusted for standard or high-resolution operation.

The prices range from $7,500 upwards.

Remote Control Projectors

One of the oldest and the most economical methods used to enhance an audio conference is to have the visuals or graphic data copied onto slides, duplicated and forwarded to the sites which participate in a teleconference. During the conference the presenter controls the display of visual materials by employing electronic devices designed for this purpose. This approach to augmenting audio has been widely used in health education.

"Random-access" equipment is especially useful in this mode of communication because a presenter can dial in the number of the slide to be seen by the participants, and thus it is not necessary to go through each slide in sequence.

Among the disadvantages of this medium, we may mention the necessity to mail in advance of the meeting the slides and the requirement to have two telephone lines or a means of multiplexing the voice line being used to signal to the projector at the viewing site.

Daystar Audio Visual, Inc., Mast Development Company and Revox Systems, Inc. sell random-access remote-control devices in the $ 1,500 range.

Personal Computer-based Graphics Generation

Personal computer-based image capture devices are similar in function to slow-scan technology. Although a variety of computer supported image capture devices are marketed in the United States, the application is as yet scant. The major suppliers of these devices in the United States are A T & T and Interand Corporation. The price is in the $ 1,200 range for the image capture/display board. The cost of the personal computer must be added.

Videotext Graphics

Although a typical viewdata system has been designed mainly for applications such as banking and shopping from the user's home, it is an educational medium which has created much interest among communications specialists in Europe and in Japan.

The best known systems in use are Prestel in the United Kingdom, Teletel in France, Bildschmirtext in the Federal Republic of Germany, Telidon in Canada and Captain Videotex, which was launched in Japan in 1984. Despite a current lack of interest in this means of communication in the United States, SONY in the Spring of 1985 began to market a computer there adapted to produce frames for videotex distribution.

In Europe, the projections that the systems would be used on a mass scale had not been realized. Hans Gassman of the Organization for Economic Cooperation and Development in Paris attributed in The Information Explosion, edited by Mick McLean, Westport, Conn. : Greenwood Press, 1985, the constraints to growth to the following:

-- the information received on videotex systems is available by traditional means (e.g. in newspapers) at less cost.

-- the systems are expensive in terms of equipment and usage cost (for example the SONY product referred to was to be sold for $35,000, although there are those in the $15,000 range in Canada).

-- fears about the security of information transmitted by these networks (for example, in banking applications).

Nevertheless, Hans Gassman expressed confidence that in spite of slow growth, the videotex will become an important factor in future communications.

The optimistic view of the potential expansion of videotext is based on the hope that consumers will use a medium which enables them to obtain graphics information from a data base and have it displayed on a television set at their convenience.

The communication process involves the following: a user must purchase a modem -- an electronic device which converts a digital bit stream from a computer to an analog signal. The analog signal is then transmitted, generally over a telephone line. Digital to analog conversion is necessary to establish compatibility with the electrical characteristics of a telephone line which is suitable for voice communication but not suitable for digital transmission. A decoder attached to the user's television set converts the analog signal to digital form, stores the pages in a buffer memory and displays these at the user's request. To access the information, the user keys the selection into a calculator-type keyboard attached to the television set.

Telewriters

Telewriting provides an economical enhancement of audio conferences. The capability of this medium to facilitate the sharing, at multiple sites and in real-time, of annotations made on an electronic surface is particularly useful in telelearning activities. The operation is simple.

Recently, a product called Optel Telewriter II PC was introduced in the U.S. We shall describe it to illustrate this kind of equipment.

Optel Telewriter II PC costs $ 4,200. The price includes a 5" x 7" tablet, voice modem, software, power support and a 99 page memory diskette. The personal computer has to be purchased at additional cost.

The exchange of voice and telewriter signals is accomplished over one dial-up telephone line.

Experiments with the system have been conducted by Harvard University to provide calculus classes to students at a remote site. Louisiana State University has used the system since August 1985 in order to offer credit courses in mathematics and science. The courses are originated at the main campus and received at several campuses located at a distance.

The New York State Department of Education has been able to offer through this medium secondary school courses to rural youth.

Computer Conferencing

Computer conferencing is relatively new. The systems are designed for interchanges among geographically dispersed individuals or groups which communicate with each other through computer terminals linked to a central computer. The central computer can store information and forward it when requested.

In contrast to audio/video systems in which the communication is established by speaking and listening, in a computer conference individuals communicate by typing into and reading from computer terminals.

Connections are generally established by telephone lines. However, satellite channels are also used for computer linkages by large volume users because of the advantages of the wide-band width of satellite links in terms of capacity and speed. Fiber optic cables are expected to increase dramatically transmission capacity in the future.

Many terms have been used to describe this mode of communication, such as computer conferencing and computer-based messaging. Typically, computer conferences are asynchronous but participants may also hold meetings in real-time.

An important possibility of computer conferencing is a packet network designed to carry digital information to accommodate many users and to reduce transmission costs. In addition, the use of a packet network assures a greater reliability of transmission than if the transmission is carried out by a public switched network. "Packets" adhere to a set of

rules, called protocols, that define the routing of the data and also enable computers "speaking" different languages to understand each other. Among the well-known providers of packet network services are GTE/Telenet and Tymnet, both of which operate world-wide.

The function of computer conferencing is as follows:

- To create and maintain materials which can be accessed at any time by geographically dispersed individuals or groups.
- To provide instruction and training either in the traditional classroom setting or at the convenience of the learner.
- To enable the learner to study in a self-pacing mode.
- To keep those engaged in collaborative projects informed with ease and speed.
- To provide graphics systems that enable scientific investigators to manipulate the graphic representations and to interact.
- To facilitate access to data against which researchers can check the validity of their hypotheses.
- To complement other teleconferencing modes.

Among the advantages of computer conferencing are:

- A medium for scientific and technical collaborative projects among peers at distant locations.
- An easy and time-efficient access to information contained in on-line data bases.
- Time zone differences are removed if asynchronous modes of communication are used. It provides an opportunity to enter a conference at any time, and also the cost of transmission may be significantly reduced if the information exchange takes place at non-peak hours.
- Computer networking is increasingly available around the world.
- Communication among multiple sites is easily established.
- Participants can enter the conference from any location by telephone.
- Creation and preservation of records which enhance accuracy in communications.
- Time for reflection is greater than in audio/visual telemeetings if an asynchronous pattern is used.
- Option to take part in long on-going conferences as well as in real-time interactions.

- A medium for the developing world's researchers to have timely access to information which often is not rapidly available by traditional means. For example, many scientists and technologists are dependent on journals for keeping abreast of work elsewhere, but which do not arrive quickly through the mail.
- Computer interactions can be easily enhanced by audio connections.

The negative aspects of computer conferencing include:

- Incompatibility of equipment caused by lack of computer standards.
- Lack of national backbone networks that are protocol independent or suitably transparent. However, great strides have been made in alleviating such problems when packet networks, such as GTE/Telenet, emerged and standardized different "languages."
- Inadequate typing skills are a serious impediment in the use of this means of communication because of possible errors in the information entry.
- Lack of cues: the success of a computer conference held

in real-time may be jeopardized if the participants do not know whose turn it is to act.

- Security problems may arise but are less severe if packet networks are used for the transmission of information.
- Poor quality and high cost of the telephone service in many areas of the developing world.

Computer Networks

In recent years, computer networks connect users around the world. Many originated in the United States. Networks of scientists include the atmospheric researchers Uninet and MFNet, which links the United States Department of Energy laboratories and universities working on fusion energy projects. ARPANET, initially developed by the U.S. Department of Defense as an experiment in computer resource sharing is now an unclassified network of the Advanced Research Projects Agency. The Electronic Information Exchange System (EIES) was developed by the New Jersey Institute of Technology. CONFER II system, initially developed by the University of Michigan and now operated by Adverted Communications systems, is able to provide for conferences with up to 1,000 users.

Bitnet is a major academic network of computers linked by a 4-wire leased telephone line. Membership in Bitnet is free but each site is responsible for the cost of a 9600-baud leased telephone line to a nearby site and two modems

for that line. The computers communicate by using IBM's Remote Spooling Communications Subsystem (RSCS). Before joining Bitnet, the technical feasibility of installing an RSCS connection has to be explored. Bitnet has more than 200 U.S. members and it is connected with the European Academic and Research Network (EARN) and with Canada's NETNORTH. EARN is the first non-specialized European academic computer network. EARN's members include universities and research centers in Austria, Belgium, Denmark, France, the Federal Republic of Germany, Ireland, Israel, Italy, Spain, Sweden, Switzerland and the United Kingdom. The address of EARN is c/o IBM, 36 Avenue Raymond Poincare, Paris 16e and the Bitnet Network Information Center is c/o EDUCOM, P.O.Box 364, Princeton, New Jersey 08540.

At the Rutherford Appleton Laboratory in England a gateway between EARN and the Joint Academic Network for academic and research institutes in the United Kingdom (JANET) is under development. Bitnet is now also linked to the Science University of Tokyo and to the IBM Scientific Center in Tokyo. High Energy Physics researchers and theorists have been using PHYSnet in addition to Bitnet.

In Sweden, COM, which stands for computerized conferencing systems, was developed at the Stockholm University Center in 1979. Used by the university, public research institutes and various Swedish agencies, it can also be accessed from North America, West Germany, Italy, France and Finland.

Great distances between Brazilian communities stimulated the development of UFRGS (Universidade Federal do Rio Grande do Sul) computer conferencing system which is used primarily by Brazilian scientists and engineers.

Cost Considerations

Computer conferencing is a relatively low-cost means of communication and can be used also with video and audio educational teleconferencing with satellite or terrestrial connections. When estimating the cost of computer conferencing services, a potential user must take into consideration:

-- the capital outlay for the communication terminal

-- the modem to interconnect with a telephone line

-- the usage cost

-- conferencing service charge

-- membership cost in a network (if applicable)

-- storage and text manipulation

Computer conferencing service charges in the U.S. are about $20/hour. Signaling speed is an important factor in determining the cost of transmission. As to network membership fee, EIES charges $95/month and about $9.50/prime time hour service and considerably less during non-prime time. Storage and text manipulation costs vary as some systems charge five cents for each message sent, others have monthly rates based on the number of characters stored.

The advantage of using conference services before installing in-house

system consists of having a better insight into specific communications needs, and thus the software can be obtained later with a better sense of requirements and often of how coordination with audio, video and fax communication can be achieved.

Sample Applications

The Research Libraries Group (RLG) is a consortium of research universities founded in 1974 which has been promoting the sharing of library resources through computer linkages. The Research Libraries Information Network (RLIN) supports collaborative programs among RLG members. For example, RLG and the British Library installed a dedicated RLIN communication line with the objective of system-to-system linkage.

Yale University is one of various institutions that use Bitnet to carry out editing activities between the Yale in-house university press editors and those at geographically dispersed sites.

Implications for the developing countries

Given the availability of inexpensive microcomputers, the improvements in global telecommunications systems, and the international access to packet network services (such as Tymnet and Telenet) that connect otherwise incompatible equipment, computer conferencing can create continuous links between the developed and the developing countries. The establishment of computer links between developed and developing nations has been tested among others by the International Development Centre of Canada. For example, from May through December 1983 more

than 100 scientists from 25 countries participated in a cross-national computer meeting on the bioconversion of lignocellulosics for fuel, food and fodder for developing nations. In 1985, a workshop sponsored by the Association of African Universities and the United Nations University in Lagos, Nigeria, emphasized the importance of manpower training in computer technology in order to have access to data bases on nutrition science.

The United Nations University has taken important initiatives toward the training in microprocessor technology of those from universities and research centers in developing countries. Thus, training courses have been organized at Trinity College in Dublin, Ireland; in Trieste, Italy; in Colombo, Sri Lanka. Others will be conducted in Bogota, Colombia and in the People's Republic of China.

Video Teleconferencing

Videoteleconferencing technology combines the audio and video media to establish both the voice and the visual interaction among individuals gathered at separate locations. The visual information is captured by a camera and displayed on a video screen or monitor. It can -- and often ought to be -- coordinated with computer communication. Freeze-frame or slow-scan video and full-motion video are the predominant systems.

In the freeze-frame or slow-scan systems, narrowband, such as voice-grade, channels are used for transmission. The visual information which can be shared at multiple sites is presented in a series of still black and white or color images. Full-motion video systems may provide for symmetrical communication in which all the participating sites have the same capability.

Full-motion (and slower-motion) conferencing enable participants to see each other and visual materials simultaneously in continuous motion either in color or black and white.

In a "two-way" video conference those at the participating sites can see and be seen as well as hear and be heard whereas in the "one-way" configuration the broadcast video is directed from one site only to one or more locations but with the audio interaction in both directions. Continuous motion images require wider transmission channels than those that are displayed in a sequential mode, and therefore are more expensive. In addition, most continuous motion visual systems connect only between two points because the cost of broadband channel linkages which would enable those at multiple sites to see the others is great.

Slow-scan Video

Slow-scan video provides a simple visual base for audio or audiographic teleconference. The medium is used for analog or digital transmission of charts, documents, figures, maps, drawings and photographs. Three dimensional pictures can also be transmitted which, as mentioned previously, audiographic devices cannot do. Images of people enable participants who do not know each other to feel more at ease as they see their counterparts.

This technology is versatile and cost effective, and thus an attractive alternative to the expensive full-motion video. Among its advantages are:

- Low cost of transmission over voice-grade telephone lines.
- Capacity to use practically any visual information captured by a television camera.

- The equipment is considerably less expensive than full-motion systems and not too difficult to operate.
- A still picture may improve the understanding of a concept
- Options in the equipment, such as fully portable units.

Among the constraints these are the most limiting:

- Lack of standards for equipment.
- Relatively low resolution.
- Slower transmission than that of full-motion.

Equipment

A typical system consists of one or more cameras at a site; a transceiver; a screen or monitor for display of stored images. At the transmitting unit a device called "freeze-frame" captures the image from the camera and "freezes" it in a fraction of a second. The "frozen" picture is converted to a slow-scan television signal; the analog signal is digitized and the digital information is stored in the slow-scan television computer's memory. The computer reads each memory location and converts the digital information into audio tones which are sent over telephone lines.

At the receiving unit, the analog information from the telephone line is converted to digital form; the digital form is stored in the receiver unit's

memory; the computer reads the information and converts the information to an analog form which can be displayed on a television monitor.

The speed of transmission depends on the channel capacity, the resolution and whether or not a compression technique is used. For example, a medium resolution image sent in an analog format over regular dial-up telephone lines requires a transmission time of about 34 seconds. If the video is sent in a digital format over a high speed data circuit, the transmission time is greatly reduced. Coding techniques which will be discussed later reduce the transmission time.

Suppliers

The best known suppliers are NEC, Colorado Video, Inc. and Robot Research, Inc. An outline of a slow-scan system manufactured by Colorado Video covers features of a widely used kind of equipment in the United States and several other countries: a black and white video system with dual memory, two cameras, mass image storage, EVM 2319 23" monitor, zoom lens and telephone jacks, can be purchased for about $13,000. If a single field picture with 256 x 240 picture elements is sent, the transmission takes 34 seconds; a full frame picture with 256 x 480 elements can be transmitted in 74 seconds; 512 x 512 picture elements in 148 seconds.

The equipment can be used in Europe because the 625 line 50 Hz European standard is compatible with the 525 line, 60 Hz American standard. Also, bridging services are available to interconnect multiple sites.

Relatively new suppliers have been emerging with portable and so-called user friendly devices, such as the Photophone of the Image Data Corporation in San Antonio, Texas. The use of the equipment is simple and there is no special installation requirement which makes the device versatile. The Photophone

referred to previously costs $8,550. The price includes the cost of a Vidicon camera, 8/16 mm lens and telephone jacks. A photobridge to interconnect three ports can be purchased for $8,890 and additional ports added for 1,815 each.

Sample Applications

Slow-scan television has been used extensively by businesses in interactive discussions which draw on visual presentations of charts, diagrams and other graphics. For example, IBM has had an in-house system since 1975 which links about thirty sites, including international ones.

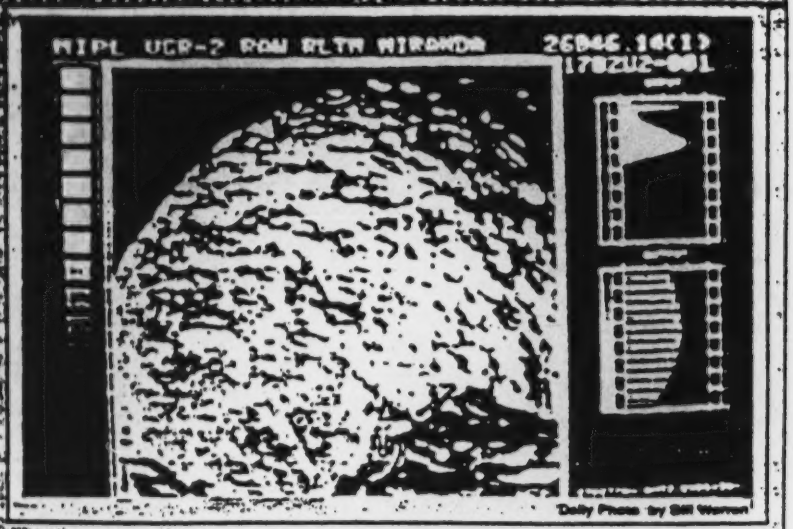
The medium has been also used widely to transmit medical information, including X-rays, particularly in rural areas.

In education, it has extended the outreach of universities to small communities and to link campuses. New York University, for example, uses slow-scan video to teach courses in medicine to students in Puerto Rico.

The following report illustrates the versatility of the freeze-frame technology:

BOULDER'S CLOSE ENCOUNTER WITH URANUS

Colorado Video's 'freeze-frames' bring the giant planet into our lives



Daily Photo by Bill Warren

This 'freeze-frame' video picture of Miranda, one of the moons of Uranus, came from NASA to Colorado Video over ordinary telephone lines.

By S.K. LEVIN

Nearly 20 years ago, Colorado Video Inc. of Boulder manufactured its first slow-scan video transmitter," a space-age device that transmits frozen TV images over ordinary telephone lines for viewing elsewhere. During the past two weeks, this device has enabled the Boulder company to become, in the words of its president, Glen Southworth, a "little window on the universe."

During its recent close encounter with Uranus, the spacecraft Voyager 2 transmitted pictures of the planet to Earth. The pictures were reconstructed into visual images by computers at the Jet Propulsion Laboratory in Pasadena, CA, and then sent over telephone lines to Colorado Video, which is storing the images in its computers. "[JPL saw pictures of Miranda [one of the Uranian moons] no sooner than we did," said David McIntosh, Colorado Video's teleconferencing specialist.

As the secondary relay point for the Uranian pictures, Colorado Video, using its special slow-scan equipment, retransmitted them to some 35 colleges and universities that make up Scan Net, a consortium of academic institutions, including CU, organized by the Boulder company to receive "freeze-frame" video stills over telephone lines.

So others could glimpse Voyager's fly-by of the solar system's third largest planet, Colorado Video loaned freeze-frame receiving equipment to the Massachusetts Institute of Technology, the Smithsonian's National Air and Space Museum in Washington and the Museum of Science and Industry in Los Angeles.

The cost for remote viewing of the Uranian pictures directly from JPL's computers through Colorado Video's freeze-frame equipment is no more than that of a long-distance telephone call to JPL.

The local community can view Voyager 2's pictures Thursday from 6 to 9 p.m., when Colorado Video will publicly exhibit its series of progressively closer views of each component of the Uranian system at its offices at 3245 Prairie, across from Arrow Office Supply.

Although Voyager 2's Uranus rendezvous has brought Colorado Video widespread publicity, the company's connection with the space probe dates back to 1977, when Voyager 2 was launched.

According to Southworth, both Voyager 1 and 2 carry a special phonograph record (a gold disk) that contains 116 freeze-frame pictures of Earth — a "message" to distant civilizations. The original pictures of Earth, provided by the National Geographic Society, were turned into audiotape recordings by Colorado Video and then into the disk by Columbia Records.

Voyager 2, which came within 51,000 miles of Uranus, now is heading for a 1989 rendezvous with Neptune, the eighth planet from the sun, and Colorado Video hopes to provide the same public viewing capacity for that planet, too, McIntosh said. But for now, he added, the company is turning its attention to the Galileo probe going to Jupiter later this year.

Colorado Daily, January 29, 1986, page 3.

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To conclude, slow-scan video is an excellent medium to supplement audio (and computer) systems. The initial confusion caused by the lack of full motion on the television screen to which we have become accustomed is counterbalanced by the relatively low cost. As mentioned previously, if transmission time is crucial to the success of the meeting, the bandwidth of the transmission lines can be increased and multiple memories can be utilized.

Full-motion

Full motion videoconferencing most resembles face-to-face meetings. It provides a sense of immediacy and has a visual appeal which other electronic means of communication do not match. Because of the continuing expansion of satellite as well as terrestrial services to most of the world, it has become a possibility for international university telelearning on parts of all continents.

Unfortunately, there are limitations to full-motion videoconferencing. These include:

- High cost of transmission, teleconferencing equipment and facilities.
- High production and operating costs.

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- Video compatibility restraints, including those of mutually incompatible codecs.
- In international conferences in addition to the cost of the services provided by INTELSAT, domestic satellite or terrestrial expenses are incurred to relay material to and from the INTELSAT gateways for transnational transmission.
- A considerable number of countries lack the necessary telecommunications infrastructure to support video teleconferencing.
- The competition for satellite slots in geosynchronous orbit may become unfair to countries which have no existing satellite technology. Thus, the developing world may have too few opportunities to obtain desirable orbital positions by the time they develop their telecommunications capacity. Fortunately the development of photo-optical cable connections later in this decade should more than compensate for the above limitation.
- "Last mile" services are at times too difficult to provide: these are the transmission services between the users' premises and the satellite uplink. Generally land lines or microwave links are used for the connection.

Full-motion teleconferences may be held in a specially equipped facility dedicated to this purpose, or in a leased facility, or even in a classroom seminar room. The potential user of this medium also can obtain portable equipment which can be brought to the site requested by the user. Full-motion video is generally in color which, of course, enhances its appeal.

If a network is created for each new event, then the teleconference is called an "ad hoc" teleconference, which implies only an occasional use of teleconferencing in contrast to an establishment of a permanent system for regular usage.

The Technology

Broad-band land lines and satellite channels are most suitable for the transmission of video signals to locations separated by a great distance. In the future fiber optics technology promises optimal opportunities because of its potential to provide virtually unlimited bandwidth and elimination of electrical interference.

A full-motion picture, represented by continuous wave forms, is referred to as "analog" transmission. In turn, if the picture is transmitted by using discontinuous electrical and electromagnetic signals which change in frequency,

polarity or amplitude, then the transmission is referred to as "digital."

The bandwidth requirements for analog transmission are expressed in cycles per second, and for digital information in bits per second. For example, telephone voice transmission requires a bandwidth of 4,000 Hertz (2Kz) -- that of a video signal may require 6,000,000 Hertz (6 MHz).

Given the high cost of analog transmission, an intensive research focus has been directed toward the reduction of bandwidth requirements. In recent years, significant advances in video signal processing led to new kinds of codecs (coders-decoders), which by compacting the signal reduce the bandwidth requirement, and thus reduce the cost of transmission.

The process of compression involves the following techniques: after a color video signal is generated by a video camera, it is coded into digital computer bits and compressed by removing redundancies such as the background which may be the same on each frame.

The techniques have effectively reduced costs. For example, since 1982, a full-motion color picture can be transmitted by using 768,000 bits of data which is one-half of the capacity required prior to the development of this approach. Before 1982, the lowest possible rate was 1.54 million bits of data per second,

which is the standard capacity figure in the U.S. and some other countries and is known as T1.

Although compression techniques produce some picture degradation, research on how to maximize video compression continues because of its potential to reduce further transmission costs. Thus, low-speed video codecs are emerging with reduction rate down to 56 kilobits - the standard digital rate of the dial-up switched telephone network. For example, the Pic Tel Corporation in Peabody, Massachusetts in the U.S. is introducing this year a videoconferencing system built around its 56 kilobits per second codec. (The codec costs $70,000 and the videoconferencing system, including the codec, about $150,000.) Mitsubishi Electric Corporation of Japan also intends to introduce a similar system.

There are two fundamentally different methods used to compress a video signal: a) interframe coding, which transmits only the changes in the picture from frame to frame, and b) intraframe coding, which concentrates on coding high detail areas of a picture at the expense of less detailed areas.

Suppliers

Among the well known suppliers of coding devices, listed in alphabetical order are: Compression Labs, Inc. (U.S.), France Cables et Radio (France),

GEC McMichael (the U.K.), and NEC (Japan). NEC developed its system in the 1970's upon the groundwork laid at Bell Laboratories and later supplied 3-Mbps codecs. NEC recently introduced a codec which offers a number of user selectable data rates ranging from 512 kb per second to 2.048 Mb per second. (It costs about $95,000.)

GEC manufactures four different codecs which employ the CCITT recommended COST 211 algorithm. The employment of an international algorithm enables users to communicate with any other codec using the same algorithm. GEC charges about $89,000 and less if larger quantities are purchased.

Western European countries have been more prepared than the U.S. to accept the common standard of COST 211. Public teleconferencing rooms, using COST 211 compatible equipment, have been established in:

Denmark
Federal Republic of Germany
France
The Netherlands
Republic of Ireland
Sweden
Switzerland
United Kingdom

In the United States, since the closing of AT&T's teleconferencing facilities, public videoconferencing rooms have been placed mostly in hotels.

It should be noted that codecs are integrated into videoconferencing systems whi can be built in configurations specified by the users. Ready-built systems, also called "turnkey" systems are available, for example from Alcatel Thomson, France Cables et Radio (FCR) in France, GEC Video Systems, NEC and others. The costs range from $150,000 upwards. The prebuilt systems, of course, reduce on-site work.

The equipment options in the audio/videoconferencing include:

- Three-tube or single-tube color cameras
- Monitor displays of up to 25 " diagonal
- Video tape recording
- Graphics devices for documents, drawings and viewgraphs
- Hard copy printer
- Motion codecs
- Freeze-frame codecs
- Voice actuated camera switching
- Automatic microphone mixing audio systems or full duplex microphone systems with acoustic echo cancelling
- Wired or wireless meeting controllers

Videoconferencing Rooms

As mentioned, video teleconferences can take place in a) a facility dedicated for this purpose, b) in a public meeting place which is leased for the duration of the conference, or c) in ordinary rooms in which portable equipment is used. The financial resources and communications needs of the user determine which option of those noted is most appropriate. In all three cases, not only must the types of equipment be considered but also the design of the room itself must be taken into account.

Consultation with national PTTs and equipment vendors will help provide an overview of what is available. Although the cost of a teleconferencing room has been substantially reduced, the minimum expenditure for a full-motion fully modularized integrated system is approximately $175,000. If it is determined that a separate facility is both necessary and financially feasible, there are several factors which must be considered:

Equipment can be divided into two groups. The basic components are television monitors, cameras, a control panel and signal processor. The other group included accessories, such as a large-screen projector, hard copier, image storage, encryption devices and high-resolution graphics. Non-technical

factors which can affect both the maintenance and performance of this equipment include heating, cooling and ventilation.

The design of the room, specifically the placement of the equipment and graphics work area, can have a significant effect on teleconferencing quality. In addition, the shape of the table and seating arrangements used and the type of lighting employed affect the kind of pictures transmitted. The success of any teleconferencing media always depends on the quality of the audio. Besides the necessary audio equipment, quality can be affected by such acoustical considerations as furnishings.

Finally, the video display orchestrates which camera picture is transmitted. Four options exist: manual switching, voice switching, continuous presence and virtual space. The first two switching techniques only permit the transmission of one picture at a time. The other two options allow a simultaneous view from more than one camera and thus more closely approximate a face-to-face meeting.

What follows is a more detailed description of what a teleconferencing room might look like. The ultimate goal is to provide a setting in which the quality of the audio and video is effective and in which the users feel comfortable.

Most videoconferencing rooms are designed for six to ten active participants.

One camera (with a zoom lens) is devoted to graphics and two or more are reserved for "people shots." At least two television monitors are used: one to view the internal picture being sent to the receiving site and another to view the transmission from that site to the teleconferencing room. A third monitor is usually reserved for graphics. The people cameras and monitors are generally placed on top of each other to insure that participants are looking into the camera lens (since they will be watching the monitor). If the group of participants is large, an additional large screen monitor may be used as well as another camera to give an overview shot of the group.

The placement and number of the cameras and monitors, in addition to group size, is often determined by the shape of the table used. With a semicircular table all participants are equi-distant from both cameras and monitors and thus more cameras are required for close-up shots. A wedged-shaped table, on the other hand, requires fewer cameras and provides a better overview but can make it difficult to see the monitors. While the semi-circular table inhibits internal discussion within the teleconferencing room, the wedged-shaped table may promote it to the extent that the remote group is left out entirely

The semicircular table tends to formalize discussions while the wedged-shaped allows informal interaction.

The cameras (and therefore what is seen on the monitors) are controlled by a pad or panel and a signal processor. The control pad allows the user to operate the equipment in the room while the signal processor (also called a network controller) is used for the transmission of both outgoing and incoming signals and thus connects two or more different sites. The control pad is located in the room itself, often embedded into the conference table but the signal processor is usually located elsewhere.

One of the functions of the control pad is to determine the video display. Four techniques were mentioned previously. Manual switching is best used in meetings where only one camera is used most of the time. In some cases a technician is used whose sole responsibility is to follow the discussion and switch cameras as appropriate. Another option which is more relevant for dynamic discussions is using cameras which are voice-switched. In this case the voice of a person speaking will activate the camera nearest him or her. The other two options discussed - continuous presence and virtual space - are innovations which attempt to reproduce the feeling of a face-to-face meeting.

In both cases the object is to allow all primary participants to be viewed on monitors simultaneously. In continuous presence, the images may be compressed from two or more cameras so as to appear as if there is one overview shot but with the detail of close-up camera angles or images simply shown side by side or in a tiered arrangement. Virtual space takes this concept one step further by assigning one camera to each participant and thus allowing each a spatial area on the monitor. (It is costly.)

The graphics camera and monitor are less complicated. A specific area of the room is set aside as the graphics area. Some arrangements use a mounted camera on a graphics stand or designate a portion of the table itself for graphics. A third possibility is to have one graphics area as just described and another camera and monitor for stand-up presentations. A last possibility is a graphics facsimile scanner embedded in the conference table.

The lighting in a teleconferencing room must provide enough illumination to see both participants and graphics clearly but must not be so harsh as to produce a glare on the monitors. The furnishings used, e.g. choice of wall and window coverings and character of tables and chairs, contribute to the atmosphere of the room but, as with the lighting and its relationship to the quality of

the video, they must also be considered in terms of their effect on the quality of the audio transmission.

Satellite Systems

Telecommunications links between the economically advanced and the developing nations are a key to international harmony and to the growth of global economy. Satellite technology bridges the gaps and facilitates the goals to which both the developed and the developing countries strive. (In a few years with photo-optic cable terrestrial means will also be able to bridge the impediments of distance, climate and technical difficulties.)

The International Telecommunications Satellite Organization (INTELSAT), a non-profit cooperative owned by 110 nations and serving an additional 60 non-member user nations, since 1965 has been a vital force in international development. Providing telephone, television and other communications services around the globe, it has also been particularly sensitive to the needs of developing nations. Its project SHARE, launched in 1984 as a collaborative effort with the International Institute of Communications (IIC) has been successful in aiding rural development around the world. INTELSAT's donation of available transponder space capacity has given badly needed health care education and services to remote villages as well as telelearning programs to urban and rural sites.

This imaginative effort has depended on effective use of satellite

technology. A brief overview of the technology and several of its applications follow.

A new frontier in communications technology was opened when the first geostationary satellites were launched into orbit in the mid-sixties. A geostationary satellite is a satellite placed in circular orbit in the plane of the earth's equator. Orbiting the earth every 24 hours, it moves at a velocity which makes it appear to stand still over a point on the equator. Any nation, given economic and technical resources, would be in a position to place a satellite in stationary orbit 22,300 miles over any part of the world. Internally, a satellite is composed of 24 receiver-transmitter pairs. Each pair, called a transponder, is capable of receiving and transmitting audio, video or digital information. Each transponder carries a separate set of signals, and thus the satellite transponder's capacity is limited as to the number of "broadcasts" it can process simultaneously. The national communications agencies determine which satellite frequencies are available for public use. The advantages and disadvantages of the various frequencies are made on the basis of interference with terrestrial microwave uses, channel capacity, design of earth stations and financial constraints. In the United States the 1974

launching of the sixth Applications Technology Satellite (ATS-6) by the National Aeronautics and Space Administration marked the beginning of video teleconferencing. Users of satellite channels (transponders) must have an earth station in order to be able to transmit or receive the satellite signals. In addition, access to the earth station has to be provided if the ground station is not located at the site of the video broadcast facility. The local connection may be accomplished by three means:

video ground cable
terrestrial microwave
private microwave

The microwave link has to have a direct line of sight to the earth station which is at times difficult to achieve. The viability of any satellite system depends on the combined power output from the satellite and the sensitivity (utilization of satellite power) of the receiving ground system. The larger the antenna, the greater is the power of the signal at the receiver. Also, the antenna gain increases as the satellite focus narrows. Some earth stations can operate only in the frequency spectrum, called C-band satellite transmission. A few satellites

operate in the 12 and 14 giga Hertz. These satellites, called Ku-band, require less expensive earth stations because the signals are stronger (5.5 to 7.6 meters as opposed to 9 and more for C-band frequencies). Earth stations can be leased or purchased. Transportable downlinks can be placed near the viewing site with a few hundred feet of cable completing the connection.

Satellite services are available to most countries through the INTELSAT system. It provides international telecommunications capacity from land to its gateways. In the United States the gateway cities are New York and San Francisco. In turn, it sells this capacity in forms such as telephone circuits and satellite video channels. Domestic satellites have to be used to relay the signals to the INTELSAT gateway. Tariffs are charged by the countries that are INTELSAT signatories. For example, a linkage between New York and London for a full-motion color video one hour, one-way video, two-way audio is presently $1,800. To this the cost of facilities at the two locations has to be added as well as the services of domestic carriers to provide the domestic connections to the INTELSAT gateway.

An important recent initiative related to INTELSAT activities has been the installation of a 45-meter solar power earth station in Wawatobe, Indonesia. Dr. Clifford Block, associate director for educational technology and communications at the U.S. Agency for International Development (AID) feels that "the earth station could help Third World nations overcome one of the major obstacles for satellite communications services in their countries: obtaining reliable electronic power." Such service, Block explains, "is virtually non-existent" in developing nations. Until now, the problem has been solved by using diesel fuel to operate earth stations, but that too is a less than desirable option since diesel fuel is expensive and difficult to transport. A solar powered system, then, would have tremendous advantages for most of the developing world.

Applications

In recent years there have been increasing efforts by the developing nations, following in the paths of the developed ones, to improve their telecommunications systems by improving their quality and extending them to uncovered areas. World Bank studies in Thailand, Indonesia, Senegal, and India among many other nations have shown the importance of good telecommunications to their educational, cultural, economic and social development.

Initially improved telephone networks will be used to provide the all-important and traditional one-to-one voice communications for business and social intercourse. Increasingly, these telecommunications networks are utilizing some of the more advanced technologies that are being transferred to these nations. In particular, satellite communications utilizing regional satellites such as Palapa in Indonesia, the Indian satellite on the Indian subcontinent, and thin route INTELSAT for telephone use in Africa and other nations that are not, as yet, served by regional satellites are being used for domestic telecommunications. One can expect that some of the higher frequency radio transmissions such as those found in the more developed nations in the form of Digital Transmission Systems will likely find their way in the

telephone systems in the developing countries in the near future.

Once in place these telephone networks with little additional investment can be extended to educational teleconferencing on an international basis and can return substantial benefits to developing nations.

Audio educational teleconferencing, for example, domestically can deliver teachers to classrooms even if the teachers are stranded in the capitals and regional school centers. Internationally, it can begin to extend the range of higher education institutions to the world scene.

The voice network can also be used for freeze-frame or slow scan television with the addition of appropriate terminal equipment. Freeze frame video can also serve as a means for delivering printed material, but that can only be read while on the screen. Low cost, slow speed facsimile equipment may very well be suitable for cost-beneficial university applications in various developing regions of the world.

The basic telephone network can also be used to provide a variety of audiographic services, again requiring some investment in terminal equipment. The benefit to cost ratio may be very attractive.

In those developing regions with regional satellites, ASEAN, North Africa

and in the not too distant future other regions in Africa, satellite transmissions can be used to provide teletext material. Indeed, it may very well be that both teletext and videotex may find greater applicability in the developing nations rather than in the more advanced nations where high speed data communications networks result in rapid and highly intelligent access to data bases. However, one need not reserve access to world-wide data bases for the developed nations. Access to the international telephone network will provide developing nation users not only educational teleconferencing opportunities, but also access to a variety of data libraries in the developed world. A relatively low cost micro-computer and a modem completes the necessary system/hardware requirements for reaching into these libraries. With many people in these nations receiving advanced training in the developed nations, there are those who are familiar with the procedures to access such information once facilities are made available.

Turning to specific applications, PEACESAT education and communciations experiments provided one of the most important early applications of satellite technology. The objective of the experiments was to link remote locations in twelve participating countries to central services through the use of the ATS - one satellite, two-way ground terminals, teletype, blackboard-by-wire

computer and slow-scan television. The system, directed from the University of Hawaii, provided programs in New Zealand, Fiji, the Kingdom of Tonga, Papua New Guinea, Trust Territory of the Pacific Islands, New Hebrides, Gilbert Islands, American Samoa and also California and Australia.

India's Satellite Instructional Television Experiment (SITE) during 1975 - 1976 tested the efficacy of electronic media for educational needs and the capacity of the country to produce programming. While the spacecraft was provided by the United States, the ground transmission and the management of the entire project was done by Indian institutions. The satellite "footprint" covered six of India's states and delivered television programs to earth stations. Radio, rebroadcasting and print materials were also used to deliver formal educational programs. Videotapes were made of all the programs in Delhi studios. Though the initial emphasis was on elementary schools, the effort appeared just as applicable to university education and also its international dimension.

INTELSAT is currently subsidizing teleseminars in thirty-seven countries by donating spare space segments to users who are selected by a committee chosen from member countries. Successful applicants must demonstrate that their projects must technically be feasible to carry out--that they test innovative uses of satellite

technology, and that the developing nations will derive benefits by participating in Project SHARE.

Project SHARE has reached out to every corner of the world. For example, the People's Republic of China has carried out nationwide educational broadcasts. A permanent "TV" University will be established because of the success of the initial experiments. It is unclear whether it will include an international correspondent.

The American Society for Microbiology started within the guidelines of SHARE a series of lectures on monoclonal antibodies, immunodiagnosis, food microbiology and virology. The Washington, D.C. originated broadcasts reach Kenya, Tanzania, Ethiopia and Nigeria. Expensive and practically unobtainable training is effectively delivered by two-way audio with occasional use of video configurations.

Another project directed toward the improvement of medical education and health care in Africa was initiated by the Memorial University of Newfoundland. The participating institutions in Africa include the medical schools at Makerere University in Kampala, Uganda, and the Kenyatta Medical School at the University of Nairobi in Kenya. Interactive audio and slow-scan television are used.

The Middle East has also benefitted from Project SHARE. The University College in Dublin has broadcast seminars on water management to the University of Amman in Jordan. The sponsor of the program, the Higher Education for Development Cooperation in Ireland, hopes that other countries in the Middle East will participate in this project because of the importance of water management in that area.

Malaysia designed in collaboration with the Midwest Universities Consortium in the United States a program which prepares students for university life in the United States. Two-way video/audio enhanced by data support are used for the linkage.

The University of the South Pacific (USPO),an educational resource for eleven small countries, separated by the Pacific Ocean, has effectively used teleconferencing for educational and regional development since 1972. At first, as a member of the PEACESAT network, later by founding its own USPNetwork the University has offered degree courses, tutorial assistance and continuing education in addition to facilitating administrative and information exchange. The programs were discontinued when the ATS satellite stopped functioning. Recently, the South Pacific Bureau for Economic Cooperation (SPEC) has made an effort to have the programs continued with the assistance of SHARE.

In the United States, a national video network serving the continuing education of lawyers in fifty-two U.S. sites was launched in Spring 1985 by the American Bar Association, the American Law Institute and COMSAT. The American Law Network (ALN) using a Ku-band technology (the capacity of Ku-band satellites to reach one meter or under receivers continues to have an important impact on the U.S. teleconferencing industry) transmits one-way video and two-way audio programs around the country. Anglo-Saxon law is applicable only to several countries and the international aspects are thus limited.

A significant effort in providing continuing education via domestic satellites was the establishment of the National University Teleconference Network (NUTN) in 1982. Originally a consortium of 56 U.S. colleges and universities, now it has 101 members who are receiving live engineering courses through the Institute of Electrical and Electronic Engineers and telecourses on medical subjects through Symposiums International.

Foreign language instruction has been enhanced by the ability of the students to receive foreign TV programming via satellites. For example, midshipmen at the U.S. Naval Academy have access to programs transmitted by INTELSAT's Atlantic Ocean satellites, by the Soviet GORIZAT satellite, by the

French Telecom spacecraft and all Canadian and American domestic satellites.

Satellite programming for language instruction is also finding enthusiastic advocates at Columbia University and on other U.S. campuses. The health-care professionals have also benefitted by instructional programs transmitted by satellites. The Hospital Satellite Network (HSN), established in 1983, distributes via Spacenet I, transponder no. 6, programs to health-care specialists in thirty-seven states. Health care education now also has an important international dimension.

Conclusion

In this brief guide to teleconferencing for higher education we shared with the reader some of the experiences of a young organization that looks toward telecommunications to facilitate transnational access to expertise in the natural and social sciences, technology, the arts, professions and humanities. Specifically, we hope to give students around the world an opportunity to learn from internationally renowned teachers -- to stimulate interactions among young academics -- to strengthen ties among senior scholars and professionals as well as ease their reach to those in other countries which they often cannot do because of excessive demands on their time. The developing as well as the developed world requires a timely access to recent advances in knowledge upon which human progress depends.

It is desirable, of course, for universities to be able to engage in interactive full motion video conferencing. However, this is bandwidth consuming and very expensive. If satellites are used as they must be now for such international teleconferencing two transponders are usually required although there is some research underway by RCA to utilize a single transponder for two-way video communications. If there is more than one up-link available and an agreement that there will be one conference manager and controller, multi-party conferencing is possible. But generally interactive video teleconferencing is point-to-point with the ability for many parties to observe and participate in the audio conference but not be seen in the video conference.

Bandwidth reduction is possible through the use of codecs which can compress the bandwidth required for the conference. Codecs are expensive as we have pointed

out and they are required at the terminals for the conference. Furthermore, there are no international standards as yet; new codecs and their associated software are coming out frequently. Nevertheless, there are numerous public facilities in Europe for providing videoconferencing on 1.5 MB/s networks using the COST 211 system.

For the industrialized nations, interactive video conferencing using codecs should be viewed as an interim solution. Throughout the industrialized world, efforts are underway to develop Integrated Services Digital Networks (ISDNs) which, it is hoped provide broadband, from a few baud for telemetering to several mega-baud for high quality television. It is not yet clear if these will be public networks, as desired by the European and Japanese PTTs or if they will emerge as a network of private networks, as it appears to be in the United States. The policies of telecommunications are confusing. Increasing use of optical transmission systems will offer lower cost wide bandwidth networks for video teleconferencing.

Asymmetric video conferencing that is two-way audio and one-way video is increasingly used in many nations for academic and other purposes.

Many of the developing countries are expanding and improving their telecommunications networks, utilizing satellite and other modern transmission modes. It is not likely that these nations will have quickly the broadband capability of the ISDN nor optical transmission systems. For some time to come the developing nations will have available to them the capabilities of the modern telephone network with the capacity to provide reasonably high quality voice transmission and relatively low rate (up to 4.8, perhaps 9.6 baud) data transmission. With these capabilities slow scan-freeze frame video

should be viewed as a solution for some years. Investments in video conferencing using codecs should be seen in that setting as a long range investment in international university education.

Meanwhile, a low capacity network can be not only an effective tool in university teaching, a stimulant to collaborative research projects, an efficient line to data bases, but also a facilitator of services which are needed if the modernization process in the industrially developing world is to succeed. In addition to the capability of this kind of network to support the applications discussed above, it affords its users and and others time to learn and to plan more wisely for the upgrading of telecommunications systems generally and for higher education in particular.

The initial network we suggest for consideration would use compatible equipment whenever possible. The system would include:

- Two-way audio with bridge capability to link multiple sites
- A telewriting device
- Projectors for pre-recorded video tapes and slides
- Computer linkages
- Slow-scan transceiver with image storage capacity

Transmission options would include public switched networks, microwave systems, packet switching for data transfer and satellite channels which are often advantageous in the developing world where landlines for long distance telephone service may be inadequate, difficult to install and maintain.

Needless to say, the state-of-the art has changed dramatically even in the short span of FISCIT's history. The direction toward more capability at lower cost will undoubtedly continue as well as the acceptance of telecommunications as a socially desirable and economically reasonable mean for dissemination of information.

The launching of communications satellites, such as Japan's BS - 2 in 1984, which bridged telephone service gaps in remote areas of Japan, is an encouraging development, hopefully to be followed by the launching of other regional satellites.

Our approach to link video/audio/computer in conferencing systems is expected to expand and improvements in text and voice store-and-forward communications will lead to increased applications of this technology.

Improvements in high resolution monitors for displays of graphics and slow-scan and compressed video will lead to a greater acceptance of electronic modes of communications while lessening the impact of current constraints.

The focus on "user friendly" devices will not abate and teletraining programs will be widely institutionalized.

The potential of optical fiber systems to provide extensive long distance transmission capacity is considered by many to be the most exciting development in transmission technology. Among the most important advantages of optical fibers are low attenuation which is the difference between transmitted and received power, the difference caused by transmission loss through lines of communication devices and high bandwidth.

The old and the new communications technologies have a potential to enrich the world of higher learning and to create tangible as well as intangible benefits for the industrialized and the developing nations. The technology, however, provides only a mechanism for the delivery of substance. The claim that telecommunications is as significant to education as the printing press may be excessive. We just believe it is the second most valuable technological innovation for learning.

Section II

Shoichi NOGUCHI and
Yoshiki NEMOTO

The Impact of the Satellite Communication Networks on Research and Education

THE IMPACT OF THE SATELLITE COMMUNICATION NETWORKS ON RESEARCH AND EDUCATION.

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In this report , we present our impression of the scenario of research and education in a highly advanced information oriented society and explain the necessity and importance of setting up, worldwide, the foundations of the basic infrastructure of this futuristic society. A powerful and versatile information network will play a very central role in this scheme.We show that a Satellite communication network is the most efficient among networks when considered in the world-wide context which covers the developed ,developing and under-developed countries.Thence we explain the technical problems involved in the construction of this satellite communication network and present briefly the design concept and the relationship between the size of the network and the system components. We cite the ATS-1 as a case study of the above-reported concept, finally we discuss the future trends in satellite communication systems and conclude this report.

In accordance with this outline, this report consists of the following sections :

[1] Introduction.

[2] The Infrastructural Requirements of Research and Education for Today and Tomorrow.

[3] The core of the Infrastructure - An Information Network.

[4] A Satellite Communication Network vs. other alternatives in the context of Worldwide Research and Education.

[5] Impact of the Satellite System on Research and Education: some projections.

[6] A Satellite Communication Network- The design concept.

[7] The ATS-1 Satellite Network - A case study.

[8] Future Trends In Satellite Communication Networks.

[9] Our Conclusions.

[1] INTRODUCTION

Science and technology has had the most revolutionary impact on the history of Humankind. The discoveries, inventions and innovations have revolutionised not only our way of living but also our thoughts and understanding. It has played the role of the most important catalyst in the ever changing human society.

The scope of the impact of this fast developing science and technology on the two driving forces of civilisation, namely, research and education can not be underestimated. Thus it is necessary to take a closer look at the current situation and see in what way we can make a wider and better use of the available state of the art in science and technology to advance the cause of research and education and pave the way for the coming era of worldwide better living, peace and prosperity.

The notable among the most recent marvels of science and technology are-

* the VLSI's (Very Large Scale Integration),
* the technology of high speed information transmission using optical fibers and satellites,
* the very high speed super computers and intelligent machines,
* the highly intelligent and user friendly multi-media work stations.

A synthesis of these technologies has given us another extremely powerful system -the ISDN (Information System Digital Network). This system shows the promise of playing a very significant role in the highly advanced information oriented society of the near future. The most significant impact is expected to be experienced in the following fields-

-The world structure of industry and economy ,

-The indigeneous cultural development of countries.

And it is also expected that, this impact will be brought about by contemporary research and education. In this context it is imperative that we plan a world wide infrastructure for research and education, which is in step with the present day science and technology and will catalyse the evolution of a better and harmonious tomorrow.

The basic guidelines that we must keep in mind are the following-

(1) The fullest possible use should be made of all the information, expertise and capability that lies scattered across the globe. Towards this goal, all the information resources and the different kinds of information processors in the world should be uniformly available for utilization by all peoples of all countries.

(2) The development of the indigeneous cultures of all countries should be encouraged. Further, the flavor of these cultures should be disseminated all over the world to promote a deeper mutual understanding among countries.

The most efficient mode of achieving these objectives is by the utilization of a world wide information network system along the lines of the ISDN mentioned above. This is the world wide common infrastructure necessary to provide the basics for the development of research and education.

In this report we investigate the key problems in research and education and show how this information network can play a very important role in alleviating these problems. Next, we study the different types of information network systems and arrive at the conclusion that a hybrid of the satellite system and the terrestrial system is the most effective network for our purpose.

This report concerns itself chiefly with the problems of general nature yet in some part the discussion may have become a little bit technical. To warn the reader who is not interested in the technical details, an asterisk mark (*) is given to distinguish the chapters that are technical. The asterisked chapters are for those

who are interested in a deeper understanding of the satellite information network system.

[2] THE INFRASTRUCTURAL REQUIREMENTS OF RESEARCH AND EDUCATION FOR TODAY AND TOMORROW.

2.1 Research.

University Research is the most important factor in the academic arena. Its impact on the development of the society is crucial. Research has a very significant influence on education. Without active research it will be impossible to offer the best of education to the younger generation. Metaphorically, research and education are as closely coupled as the wheels of a car. Quite naturally it follows - for the future development of our society, the crying need of the hour is to chalk out a plan that will evolve an environment congenial and conducive to the advcancement of research . The next step would be to find ways of realising the plan.

The depth and span of research and technology has grown enormously. At this juncture it is a very important necessity to synthesize, harness and utilise the enormous wealth of information and expertise that is scattered all over the world. It is true that modern technology has made distances shorter and brought us closer than ever, yet, as far as the acquisition and organisation of the knowledge that lies geographically scattered all over the world and its uniform dissemination

is concerned there is a lot to be done. With this objective in mind we propose the following-

(*i*) A new information exchange system in a new media environment.

We should construct a new type of information exchange system which will include not only the ordinary telephone, fax, mail system etc. but will also offer a media for meetings and small conferences.

It is quite certain that such a highly qualified information exchange system between researchers will play a very important role in the promotion of research activity and will become an indispensable utility in future society.

(*ii*) The installation of supercomputers and large special purpose computers.

In order to facilitate the very specialised and highly advanced research activities the installation of very large computer systems, highly qualified image processors for CAD and CAM, Knowledge processing engines and large special machines for each research field will be required.

It will be quite impossible to instal these large information processing resources at several places. The special purpose large machines may be installed at each site based on the research activity carried out on that site.

(*iii*) Organisation of very large data banks and knowledge banks. These 'banks' would deal in -

(a) Ordinary library type information,

(b) Typical methodologies developed in each academic field,

(c) Standard data utilized in research,

(d) Typical algorithms for problem solving *e.g.* new computational algorithms for solving differential equations.

(e) Knowledge banks of expert systems *e.g.* in medicine.

The above-mentioned data each composed of the data itself , the document, its image and other components of its data type should be of multi-media structure.

2.2 University education.

Universities are in the all important central role of supplying the society with trained young persons. Since the development of our society is critically dependent on these young men and women ,and, the training they have received at the university , education assumes a very profound and significant role in the moulding and advancement of society.

But in this very rapidly changing society it seems to be difficult to provide excellent education to the young people. This problem is faced in varying degrees in all countries - developed , developing and underdeveloped. In this perspective, it is very important to chalk out a plan that envisages a world wide educational system which may be utilized by all peoples. In this section we attempt to answer the question ' *what type of support system for education should be developed?* ' .To be more specific and for the sake of clarity, we consider the general system of university education, analyse its contents and then propose an appropriate supporting system.

University education may be broadly classified into three levels, namely,

(a) Elementary level (common field) : this layer concerns objects like language, basic mathematics, elementary sciences etc.

(b) Middle Level (Elementary specific field) : at this level a broader view of specific subjects is offered e.g. Physics , Chemistry, Mathematics etc. in the department of science, History, Literature, Economics etc. in the department of Humanities and Machinery, Electronics, Aeronautics etc. in the department of Engineering.

(c) Advanced level (specific field): this covers the post-doctoral curriculum and is very specialised and deep.

At each level several lectures may be packed into a 'unit'. Quite naturally, if the services of distinguished Professors could be made available to several young students the results would be very desirable. Thus, if we could pack the lectures of such famous Professors into 'unit's and use these 'unit's through our proposd media we can very rightly expect the resulting education to be excellent both in terms of quality and quantity (in terms of the large no. of students benefitted).

If such a 'unit' structure is available the universities in each country can organize their own most appropriate curriculum freely considering their respective requirements. Especially, since the lectures in level (a) are very common and fundamental, our proposed system will be very effective at this level.

In the (c) level structure, the objects of the field of education are very specialised and deep, there are normally very few Professors who are experts in a certain field. Thus at this level the new scheme is more of a necessity.

[3] THE CORE OF THE INFRASTRUCTURE- AN INFORMATION NETWORK.

In the earlier section we have stated the requirements of an appropriate infrastructure that will support research and education at present and in the coming future. It is needless to say that these proposed support systems are very large and extremely expensive. The proposition of such a prohibitively expensive support system in a worldwide context sounds self-defeating. That takes us to the crux of the problem - given the fairly limited and unevenly distributed resources, it is impossible to have several such large installations all over the world. The only way we can overcome this problem and be able to distribute the oppurtunity of utilizing these systems, somewhat uniformly, all over this world, is by constructing a worldwide information communication network.

The idea is illustrated in fig. 1. Any or all of the information resources, scattered over the globe, may be utilized for research and education from any geographical

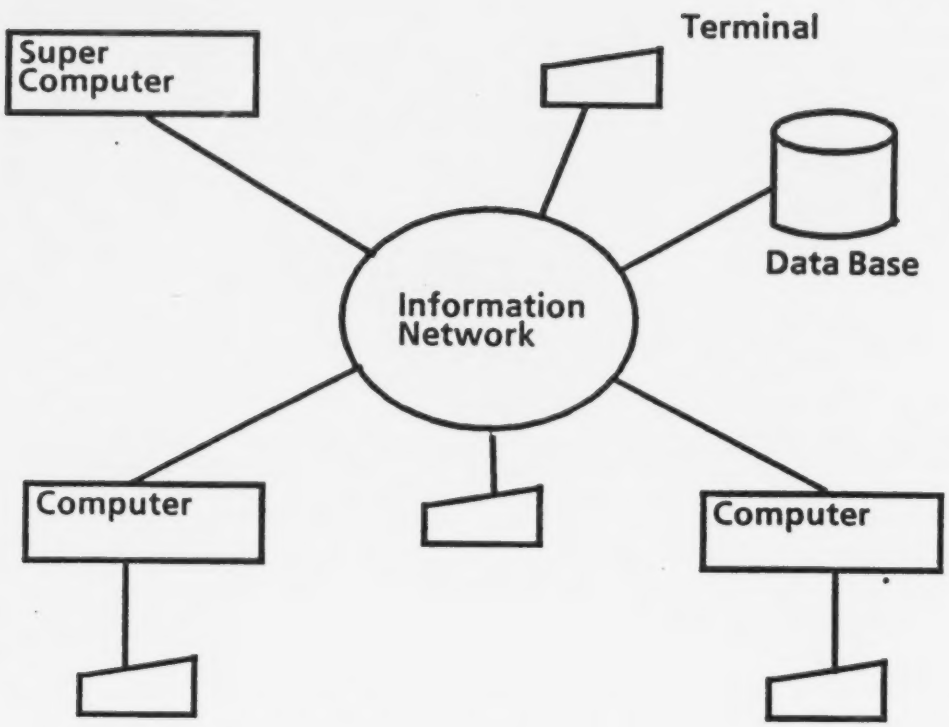


Fig 1 Information Network System

location on this earth by connecting these resources to an information network. Every user in the network is free to access information through the network. This will in fact lead to a situation where the user, say A , will be looking at the network as a massive virtual system dedicated to him. This relation is explained in fig. 2.

This leads to the next step of the problem : What kind of design and technology should we adopt to build this highly qualified information network? The basic design requirements that should be kept in mind before answering this question are the following -

(*i*) The network should have the capability of connecting m points to n points freely and with ease.

(*ii*) The channel capacity of the network must be large enough to transmit multi-media type data e.g. speech, documents , images etc.

The basic technological requirements of this system may be broadly categorised under the following headings -

- the hardware,
- the network architecture,
- the network system software and
- the intelligent interface of the system with the user.

In this report we will concentrate mainly on the network architecture aspect of the problem.

3.1 OUTLINE OF AN INFORMATION NETWORK.

3.1.1. Basic Technology for the Information Network construction.

In this sub-section, we survey the status of the present day technology related to network construction. The technology may be broadly split into two classes-

- Hardware and
- Software.

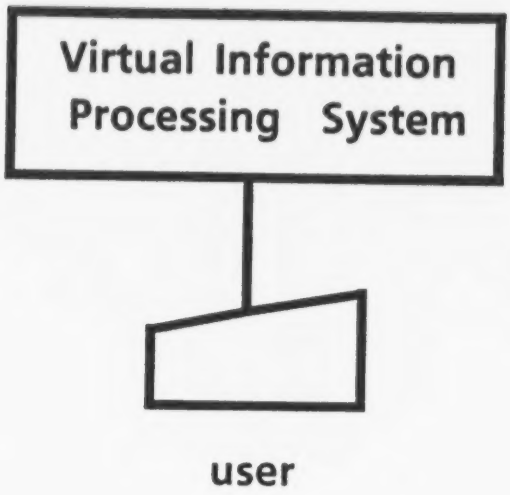


Fig 2 Virtual Information Network System

The software is indeed a very important part in the construction of an information network, yet, due to lack of space, we do not elaborate much on the software issue. The most important building blocks of the hardware technology concerning our network are the VLSI's, Optical fibers and Satellites.

Among these VLSI's is the most elemental. In the following lines we explain the advances that have been made in LSI's and its impact on communication and computer technology.

The advances in LSI technology is well realised if one takes a look at the progress achieved in the technology of memory chips. This is illustrated in fig. 3. The figure shows, on an annual basis, the development of the memory chip technology and and the remarkable trend in it's cost . The important conclusion is that we can take the use of 1M memory chips for granted. Similar remarkable feats have been achieved in other fields also. For instance, in the optical fiber technology present developments allow us to use transmission lines with a channel capacity of 400 Mbps. In computer technology we have achieved the incredible processing speed of 100Mips. And the satellite has opened up a new vista in communication technology with the possibility of connecting any two points on this globe.

Fig.4 relates the technological developments in communication networks, computers and LSI's . From this figure we can easily see that the 80's is the decade for unification of communication and computers. This will usher in the the new era of the Information network.

We have attempted to give a very global idea of the basic building blocks that will be required in the construction of the proposed worldwide information network-from the hardware point of view. Along similar lines we must give a serious thought to the plan of the academic information network for the research and education on a world wide scale.

3.1.2. The Logical Structure of the Information Network.

An information network has three types of functions-

(*i*) Information transmission,

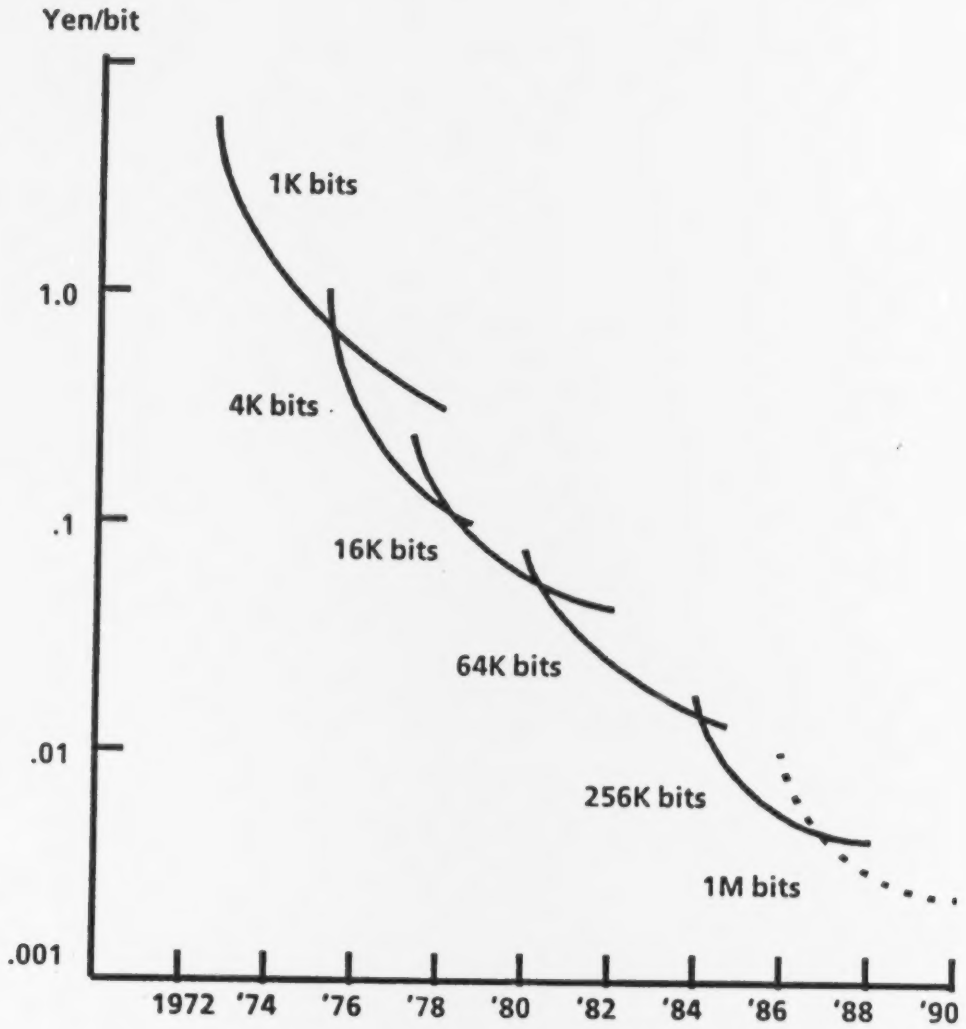


Fig 3 The Development of Memory Chips

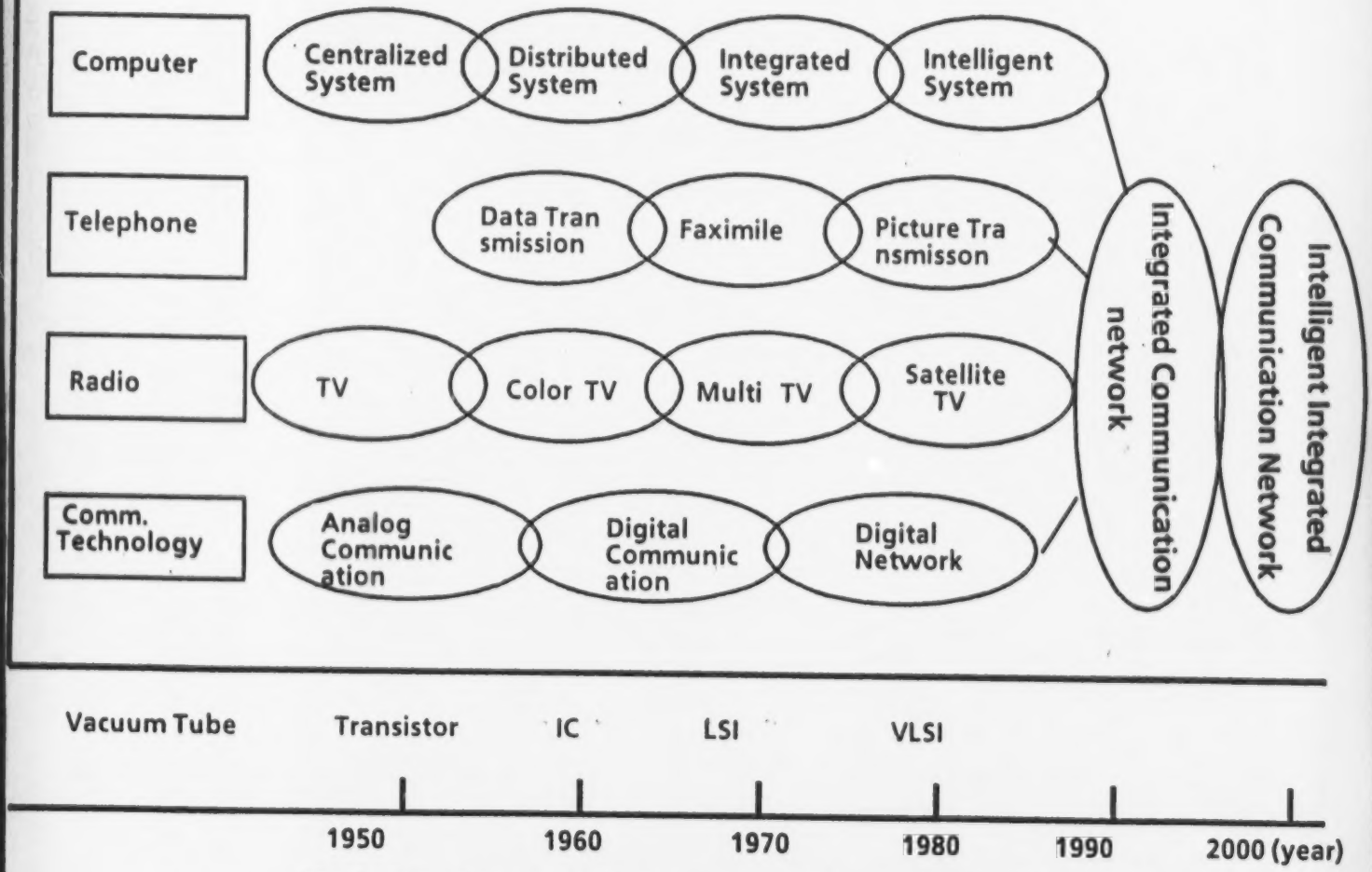


Fig 4 Development of Communication , Computers and LSIs

(*ii*) Information exchange, and,

(*iii*)Information processing .

These functions are realised in three layers of a network which has a hierarchical structure in its logical form. It is very important to recognise globally the general structure of the information network in order to understand why satellite communication plays a very important role in the network. A global representation of the network is given in fig. 5.This network shows a four layer structure as the physical layer is also included. Layer 1 is the physical layer and its function is the control of the physical device.

Layer 2 is the information transmission layer it controls the transmission of information e.g. packets.

Layer 3 is the information exchange layer controlling , as the name suggests, the exchange of information.

Layer 4 is the layer for information processing. Its function is the control of information processing and it directly interfaces with the user. This layer is very important because it is directly related to the users utilization of the network.

This logical representation depicts our proposed network architecture. Layers 1 , 2 and 3 form a subclass of the information network system called the communication network system.

Now we must consider- in what way the satellite can contribute to this information network system. We will show in the next section that the satellite may have a powerful impact on the layers 1 , 2 and 3.

[4] A SATELLITE SYSTEM. VS OTHER ALTERNATIVES IN THE WORLDWIDE CONTEXT OF RESEARCH AND EDUCATION.

4.1. Fundamental characteristics of a satellite system.

In the last section we have mentioned that a communication network has two key functions viz.

(*i*) information transmission, and,

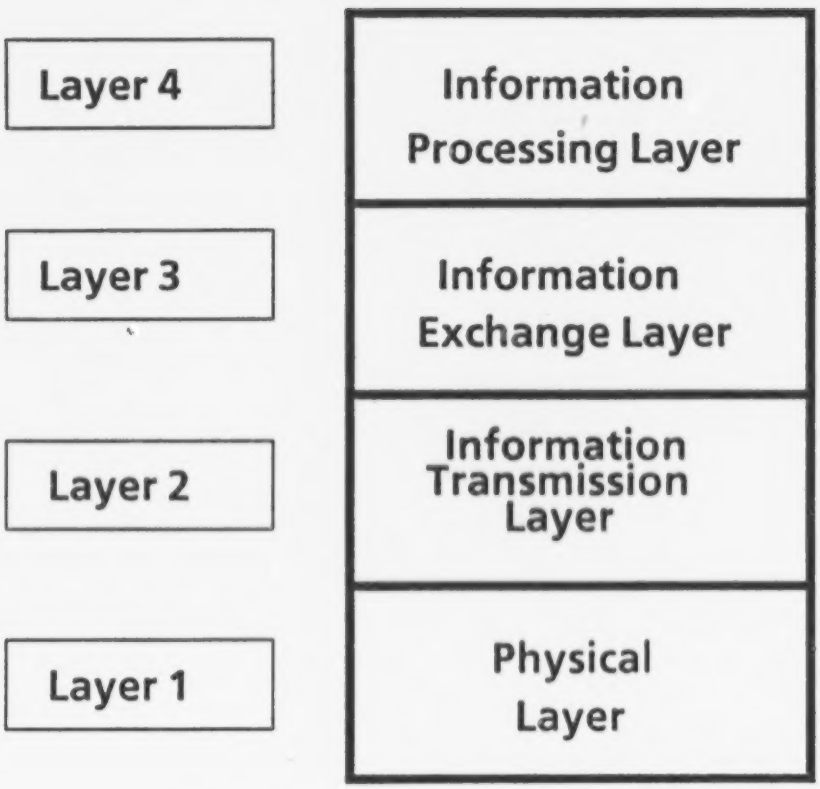


Fig 5 Logical representation of Network

(*ii*) information exchange.

Considering this level of the communication network, there are several approaches to network design. The typical components which are available at the present day technological level are -

(a) co-axial cable,

(b) micro-wave,

(c) optical fiber, and,

(d) satellite.

Considering the future information transmission system, the most appropriate components among those listed above would be the optical fiber or the satellite. We draw a comparison between communication systems composed of optical fibers and satellites respectively. We have used the data published by NTT (Nippon Telephone & Telegraph company). This is shown in Table 1. We investigate the relative merits and demerits of the two systems on the following important points.

i) Information Transmission Capability-

Optical fibers offer a channel capacity of about 5,000 ch/unit and this may be extended to a figure of 10,000 - 50,000 ch/unit in the near future. (1 ch = 64 kbps). On the other hand, the satellite system CS-3 and its successor has a channel capacity of 10,000 - 50,000 ch/transponder. Thus, as far as channel capacity is concerned the difference between the two systems is not very significant.

ii) Information Transmission Delay-

The satellite hovers in a position 36,000km above earth which results in a delay of roughly 0.275 secs in message transmission. On the other hand the optical fiber system has some delay at each repeater and in the exchange system, yet it is not so remarkable as in the case of the satellite system.

From this point of view the satellite system is not suitable for an online system which requires very quick response. But the system we have in mind - the system

System	Capacity	Repeater Spacing	Introduction
Optical Fiber F400	5,760ch	20km	Dec. 1982
Satellite CS-3	10,000~ 20,000ch		1988

Table 1

to support research and education - does not really get affected with this time delay.

iii) Information Exchange Capability-

In a communication system, the most basic function is the establishment of a communication link between the sender and the receiver. We address this problem to a terrestrial system and a satellite system and then compare the relative merits and demerits of the two systems.

(a) The terrestrial system: In this case the exchange system at the the nodes of the network should be capable of establishing a path linking the sender to the receiver. This is shown in fig- 6. The overall system which performs this task becomes very complex and the total cost of such a terrestrial system is expected to be exorbitantly high.

(b) The satellite system: The satellite system on the other hand has complete connection capability without any exchange equipment. This is illustrated in fig- 7. Any point x can transmit information to any other point y via the satellite with remarkable ease. We can say the satellite has exchange capability built into itself.

The satellite has other associated problems. Satellite uses space as its communication media and this space is shared by several users. This means that the media is like a multi access channel. Thus, if there is no control over the usage of this channel the problem of information collision will occur quite frequently during transmission. Thus , we have to develop and implement a protocol that will take care of this collision problem in the satellite system. At present, there are several protocols which support efficient utlisation of satellite communication systems.

4.2Worldwide network and the satellite system.

In this sub-section, we consider the various important roles played by the

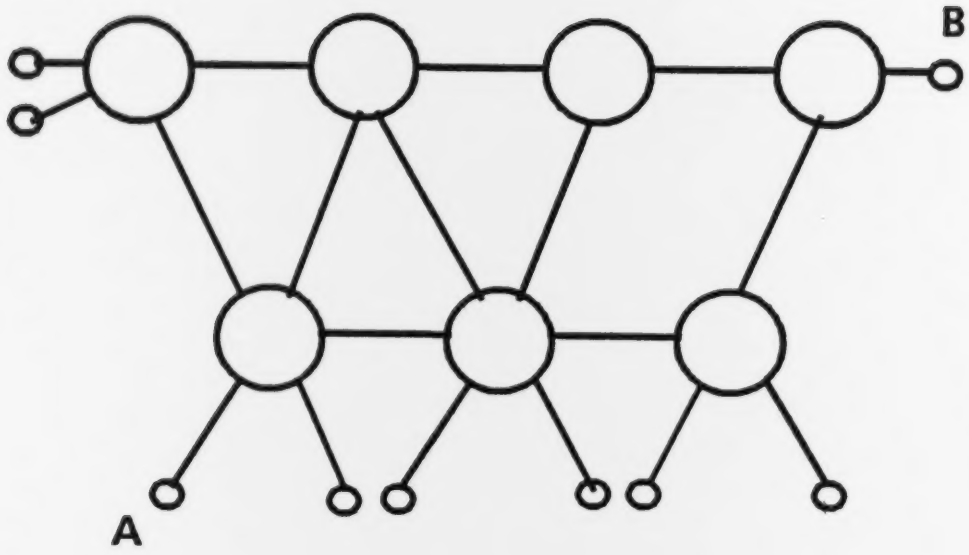


Fig 6 Terrestrial Network System

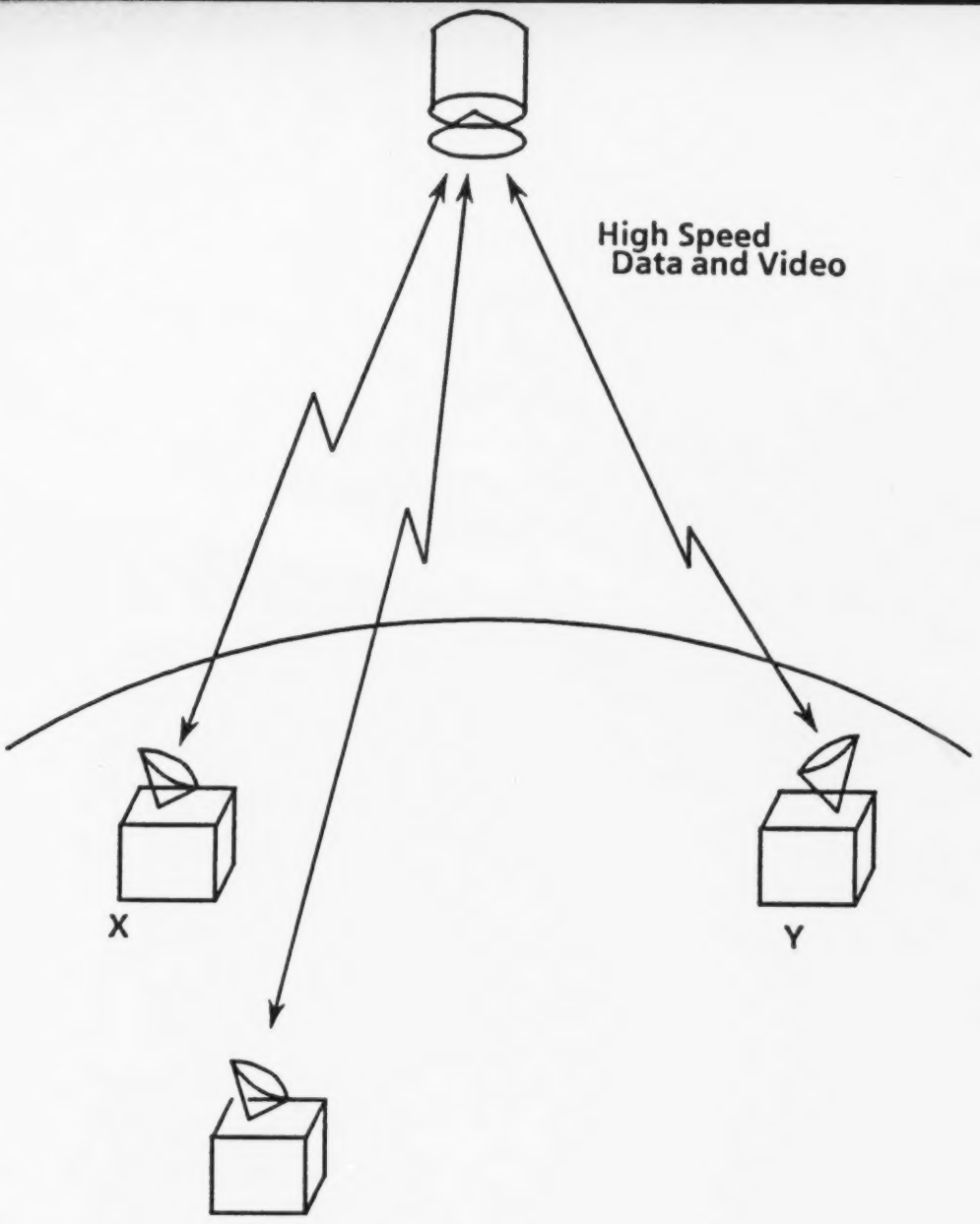


Fig 7 Satellite System

satellite system vis-a-vis the terrestrial system in a world wide network system.

a) The terrestrial network system and the satellite system.

In 4.1 we have explained that the terrestrial system becomes very complicated and expensive in a world wide communication network. Thus, if in a developing country an attempt is made to build a complete communication system based on the terrestrial concept, it will certainly take several years for its completion. Needless to say , it is quite impossible to utilise the network function until the construction is completed. On the other hand , given a satellite , if some channel is ready we may utilise a part of the network by building a small earth-station. This possibility of ready utilisation stems from the wide coverage function of a satellite. This is illustrated in fig- 8. A single satellite can cover almost 1/3 rd of the earth's surface. Thus the whole world can be covered by three satellites. This three satellite system can send messages from any place on the earth to any other place. Moreover the satellite system may be shared by several other applications and may attain optimum performance.

b) The flexibility and adaptability of the satellite system.

When looking at the world wide activity, there will certainly be variations in the level of activity at different places and at different times. At some time t, some part in the network will be experiencing a very high level of activity while other parts may at that time be comparatively inactive. By a high activity we mean a high rate of information transmission and low activity means , obviously, light traffic.

In the terrestrial system, each node has a limit on its maximum capacity and there is no way in which it may deal with traffic heavier than this limit. On the contrary, the satellite system, even though it does have an overall limit on channel capacity, there is no limitation on the traffic in each district node. It is capable of adjusting the whole traffic by carrying out an optimum scheduling . This means that the satellite system has a higher adaptability function than the corresponding

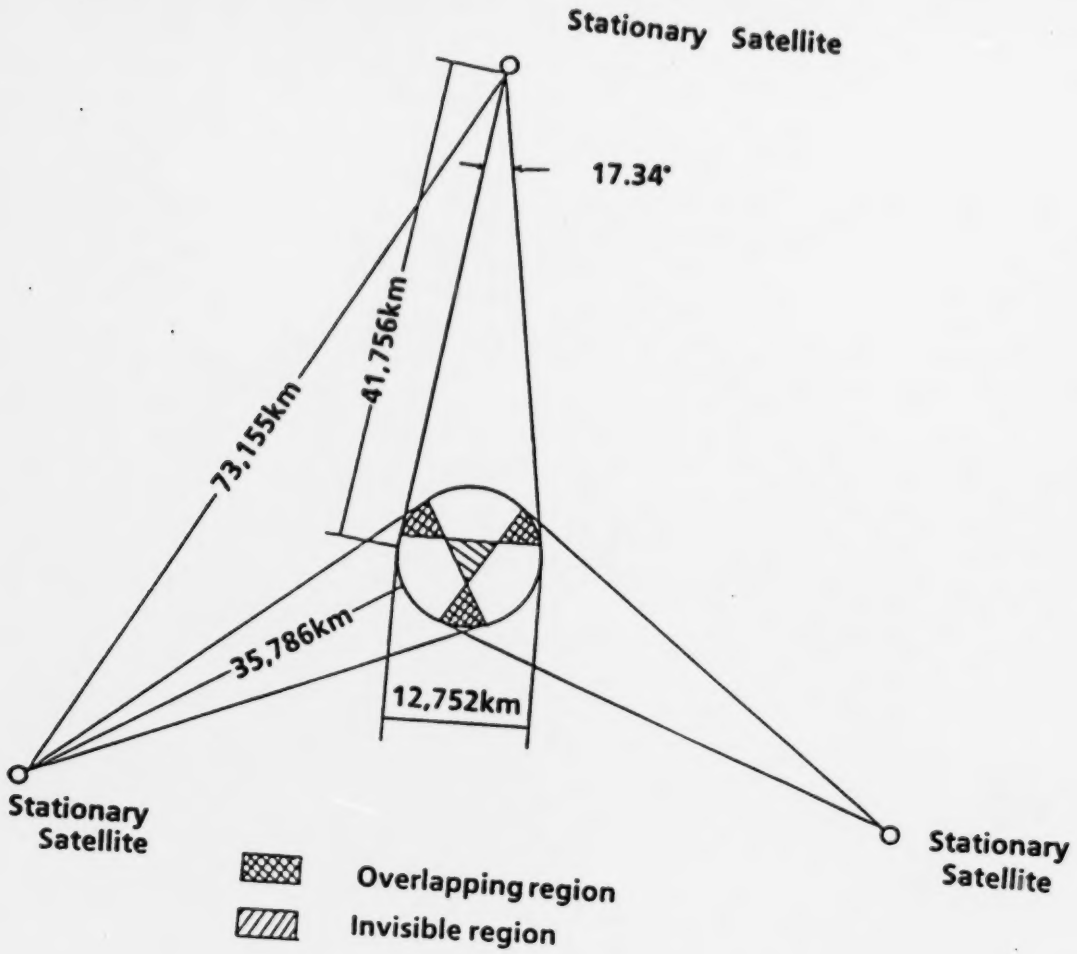


Fig.8 Geometric Arrangement of Stationary Satellites

terrestrial system. In other words, in a world wide network system , the satellite system can utilise the valuable channel dynamically based on the activity at each site, and this yields a higher performance under a lower channel capacity when compared with its terrestrial counterpart.

c) Broadcasting capability.

In a mutual information exchange system or in an educational system it often becomes necessary to send a piece of information - maybe a lecture - simultaneously to several places. A satellite network has this broadcasting capability as one of its inherent functions.

d) Access to network.

In the ordinary terrestrial system, a new connection line has to be established every time a new user wishes access to the network. On the other hand , in the satellite system the user only sets up a ground station and thereby he is capable of accessing the network freely. Over and above, in a satellite system , we may utilise the services of a mobile station which may be an aircraft, an automobile , a ship or anything that can be moved with ease from one place to another , as and when the neccessity arises.

Considering these characteristics, it follows that the satellite system offers a very powerful means of information transmission in our supporting system.

Conclusions.

It is apparent, that when considered on a worldwide basis there is no viable alternative to the satellite system in the construction of a global information network. On the other hand small local networks based on terrestrial concepts- microwave or optical fiber- do have fairly good performances. Considering the various characteristics and the several attractive features of the two concepts , in the worldwide network operation context, it may be concluded that a global satellite information network system in conjunction with the local terrestrial network systems will offer the most cost-effective and appropriate worldwide

information network. And such a network will indeed form the bulwark of research and education in the future society.

[5] IMPACT OF THE SATELLITE SYSTEM ON RESEARCH AND EDUCATION : SOME PROJECTIONS.

5.1 Estimation of network utilitisation- So far, we have been proceeding with the assumption that a network system will provide the basic infrastructure for university education and research in the coming new age. The question is -what will be the level of utilisation of such a system? An exact answer to this question is well nigh impossible, but we can make a rough estimate and predict the growth rate of the utilisation based on figures available on some of the existing similar systems e.g. INTELSAT etc.

INTELSAT is a commercial satellite communication system serving telephone and TV etc. on a world wide basis. The contents of the service are in some way similar to our supporting system. Thus we can estimate figures on utilisation etc. by studying similar figures on the INTELSAT system. Fig- 9 shows the increase of traffic in telephone and TV in the INTELSAT system. Specially since 1965, the total traffic has shown an annual rate of increase of more than 20% and in recent years the growth is still about 10% in the case of telephone channel utilisation. In the case of TV there is a remarkable annual growth rate of 25% and this indicates that the usage of image transmission may become a very important facility in the network in the very near future.

We also have the example of INMARSAT. This is a small scale satellite enterprise and is engaged in the very specialised job of providing navigation information to seabound ships on a world wide scale. The content of information is basically telephone and telex. As in the case of INTELSAT, the figures corresponding to INMARSAT showing the increase in traffic is given in fig-10 .

From the above examples, we can project that the information network

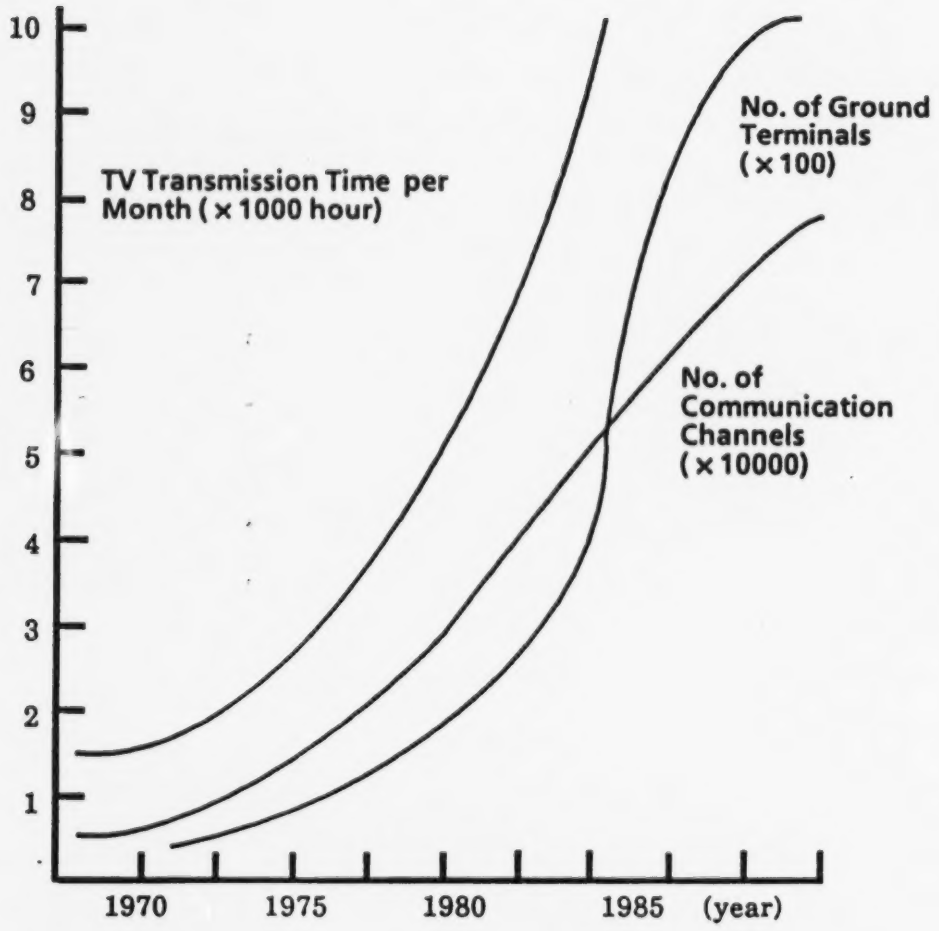


Fig 9 Development of the INTELSAT SYSTEM

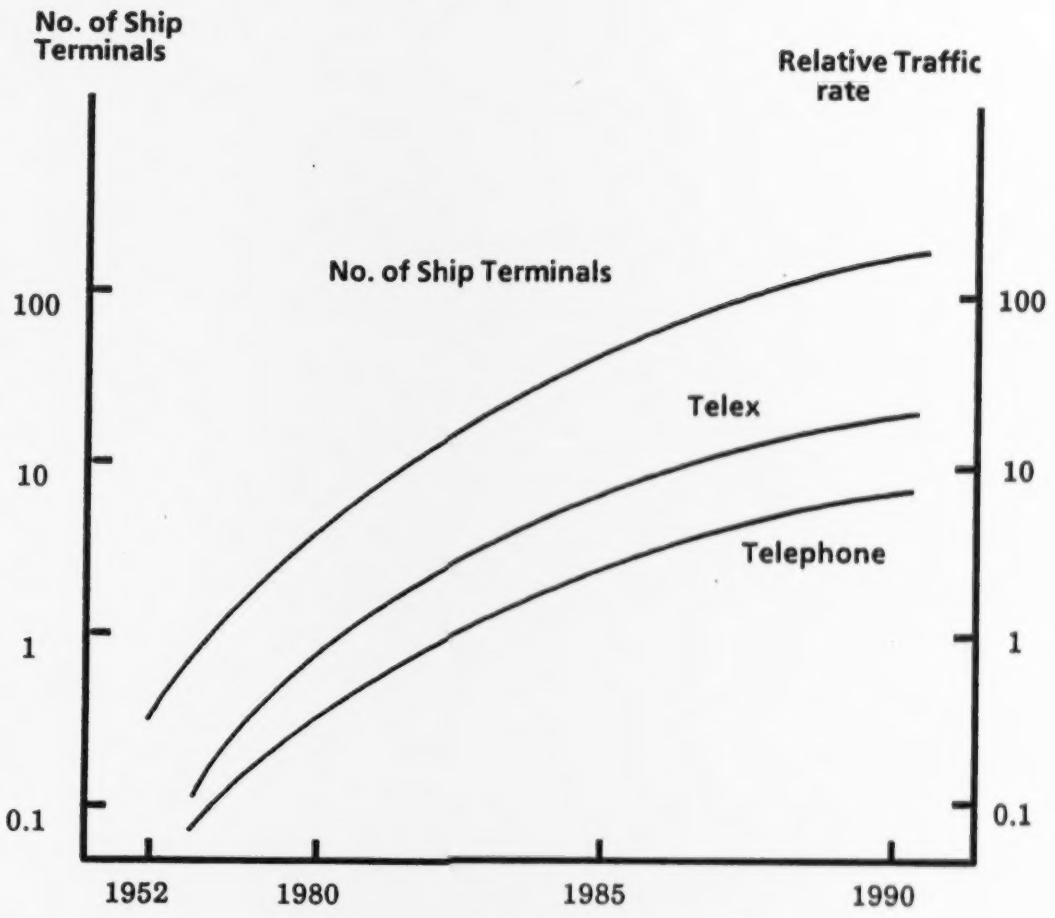


Fig.10 Development of INMARSAT System

system for education and research will in the near future be dealing with a massive amount of important information and the total traffic in the network will show a very rapid increase and that it will become a very important infrastructural facility in the world wide information exchange system.

4.2. Example of the education service system in Japan.

In this new media age, a lot of new businesses in the form of VAN (Value Added Network) are getting started in several fields in Japan. Specially, the field of education is expected to be a great market for VAN business.

In this report we show two examples of VAN in Japan.

(a) VAN for primary school level education. The outline of this system is as follows; The system consists of a central large IBM computer, several mini computers as sub-center machines and several videotex terminals serving as information outlets for the students. Any person can subscribe for a membership of this VAN network by paying a reasonable fee. A member receives a personal computer with a videotex terminal as part of the membership deal.The personal computer is connected to the nearest mini computer in the network. This system is very similar to the TERIDON system and it broadcasts a lot of the educational software utilising the image transmission technique. This system can support a student to study himself . The system at present covers- Japanese, English, Mathematics, Physics, Chemistry etc. and it spans the education beginning at the level of the 4th year of primary school up to the 3rd year of the middle school curriculum. This planned curriculum covers, almost in entirety, the stipulated syllabus for the high school examination in Japan. The system is now under development and is expected to provide a good facility for the primary and middle school students.

(b)VAN for High school level. In Japan there is a very stiff competition in the University entrance examinations. This has resulted in the sprouting of

several private schools which coach students for these entrance examinations. This school business is quite flourishing in Japan and it is growing every year. Under these circumstances the planning of VAN for high school education has been started. This system uses the bidirectional CATV for information exchange. This year onwards the system is expected to be operational and lessons will be given on a test basis for the entrance examination. The first broadcast of each lesson will be on a Wednesday and it will be subsequently repeated 4 times in the following 6 days. The system will accept students' queries from the CATV and the teachers belonging to this system will answer the queries through the CATV.

At present 1,500 persons are reported to have joined this network and it is expected to grow rapidly in the near future.

These are examples of practical realisations of an information network system for education. The impact will be observable in the very near future. By considering several such examples , one can be fairly convinced that a similar effect on a much more massive scale will result from the world wide information network system. We believe that it is time to start considering the world wide education system by utilising the information network system for the people of the developed, developing and underdeveloped countries.

*[6] A SATELLITE COMMUNICATION NETWORK- THE DESIGN CONCEPT.

In this section we give the general design principle of the satellite network to understand the characteristics and the capabilities of the network system. By this consideration we can estimate the transmission and processing capabilities by setting the system parameters such as the size of the antenna of the ground station, transmission power of the ground station and so on.

6.1 Design principle of satellite system .

In order to understand the general prototype of the satellite system we give the configuration in fig- 11.

In this system the fundamental physical parameters, pertaining to the system design, are the following-

(a) Sending system-

1. Frequency band , H MHz
2. Transmission power, P_s dB
3. Antenna gain A_s dB
4. Feeder loss F_s dB

(b) Propagation channel-

1. Propagation loss L dB

(c) Satellite system-

1. Receiving antenna gain S dB
2. Noise power density N_s dB/Hz
3. Transmission power P_{sa} dB
4. Transmitting antenna gain A_{sa}dB

(d) Receiving system-

1. Antenna gain A_r dB
2. Noise power density N_r dB
3. Feeder loss F_r dB

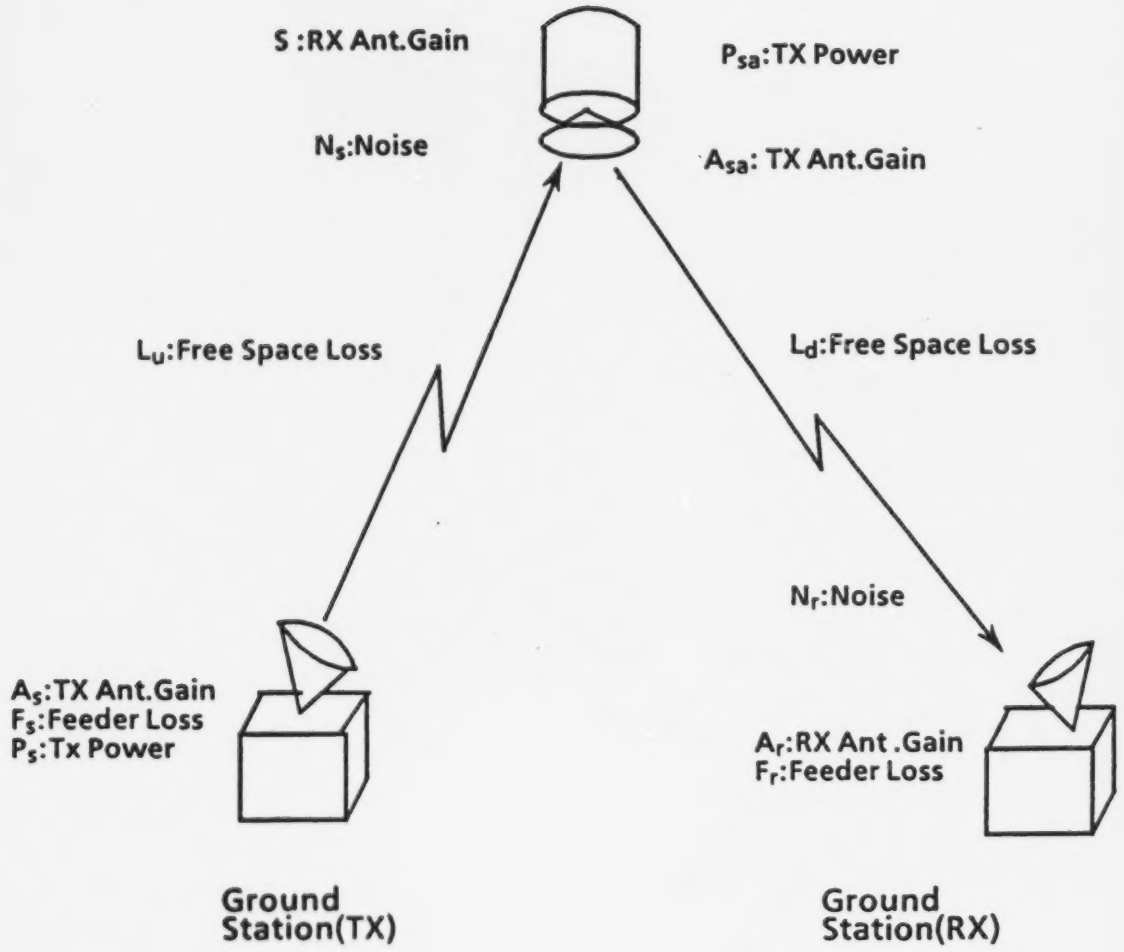
These parameters are all represented in dB except for the frequency band which is in HMHz. Using these parameters we can estimate the C/N_0 of the uplink and the downlink by the following procedure respectively. By estimating this C/N figure , the system performance is easily evaluated.

Procedure to evaluate C/N_0 :

(1) Receiving power of the satellite V_t is given by

$$P_s + A_s - F_s - L_u + S = V_t \text{ dB} \quad \ldots\ldots\ldots\ldots (1)$$

$P_s + A_s - F_s$ is defined as EIRP (Equivalent Isotropically Radiated Power)



RX:Receiving
TX:Transmitting

Fig 11 The Dominant Parameters in Satellite Communication

Then the C/N_0 of the uplink is given by

$$(C/N_0)_{up} = V_t - N_s \quad \ldots\ldots (2)$$

$V_t - N_s$ should be large enough for the required information transmission.

(2) Receiving power V_r in the ground station is given by

$$P_{sa} + A_{sa} - L_d + A_r - F_r = V_r \quad \ldots\ldots\ldots\ldots (3)$$

Then the C/N_o of the downlink is given by

$$(C/N_o)_{down} = V_r - N_r \quad \ldots\ldots (4)$$

by eqns (2) and (3) the total $(C/N_o)_t$ of this satellite system is given by

$$(C/N_o)^{-1}{}_t = (C/N_o)^{-1}{}_{up} + (C/N_o)^{-1}{}_{down} \quad \ldots\ldots\ldots\ldots (5)$$

eqn (5) means that $(C/N_o)_t$ is for a unit frequency. Thus the total (C/N) is given by the following equation.

Let H be represented by MHz, then

$$(C/N) = (C/N_o)_t - 60 \log_{10} H \quad \ldots\ldots\ldots\ldots (6)$$

Using eqn (6), we can estimate the performance of the satellite system. We give some examples in the Ka, Ku and C- Band in Table-2. By setting the moderate system parameters the capabilities of a satellite system in the K-Band is given in Table 3.

[7] THE ATS-1 SATELLITE NETWORK - A CASE STUDY.

NASA (National Aeronautics and Space Administration) in USA has launched six spacecrafts as part of the NASA Satellite Application Technology Program. The aim of this program was to combine investigations in satellite communication with other experiments concerning satellite applications.

ATS-1 (Application Technology Satellite-1) , the first satellite of this program, was launched on December 6, 1966. It achieved a geosysnchronous orbit at 151 W longitude, which is somewhere south of the Hawaiian Islands. ATS-1 is a spin-stabilised, cylindrical structured satellite of diameter 147cm and length 135cm. The sketch of ATS-1 is shown in fig. 12.

	Frequency Band	Ka-Band (30/20GHz)	Ku-Band (14/11GHz)	C-Band (6/4GHz)
1	TX Power(dBm) Feeder Loss(dB) Antenna Gain(dB) TX EIRP(dBm/CH)	43.0 2.0 53.7 94.7	43.0 1.5 47.3 88.8	43.0 1.0 39.8 81.8
	Free Space Loss(dB)	213.1	207.2	199.7
2	Rx Antenna Gain Input Level(dBm/CH) Noise Power Density of Rx System	36.0 -82.4 -167.6	35.5 -79.9 -170.1	25.0 -90.9 -169.7
3	Total Gain(dB) Output Power(dBm/CH) TX Antenna Gain TX EIRP	110.0 27.6 36.0 63.6	110.0 27.1 37.0 64.1	110.0 17.1 25.0 42.1
	Free Space Loss(dB)	209.5	206.0	196.1
4	Antenna Gain(dB) Feeder Loss(dB) Input Signal Level(dBm/CH) Noise Power Density of RX System	50.2 0.1 -95.8 -173.7	46.1 0.1 -95.9 -174.6	36.2 0.1 -117.9 -176.4
5	Up-Link(C/No)v Down Link(C/No)d Total(C/No)(dBHz)	85.2 77.9 77.2	90.2 78.7 78.4	78.8 58.5 58.4

1.Ground Station 2.Satellite RX 3.Satellite TX 4.Ground Station 5.C/No

Table 2

TX				RX			FUNCTION																			
							Color TV			Telephone·PCM								FAX			DATA					
Φ_t	Output Power of PA (watt)	Up Link C/N_o (dB·Hz)	Satellite EIRP (dBm)	Φ_r	Down Link C/N_o (dB·Hz)	Total C/N_o	64 Mbps	32 Mbps	6	1ch	2	4	8	10	20	40	60	9.6 Kbps	24	48	0.1 Kbps	1.2 Kbps	9.6	24	48
2	20 (Solid Amp)	73.6	22.6	1	53.6	53.5												○			○	○			
				2	59.6	59.4												○	○	○	○	○	○	○	
				3	68.0	66.9				○	○							○	○	○	○	○	○	○	○
				5	72.5	70.0				○	○	○						○	○	○	○	○	○	○	○
				10	78.5	72.3				○	○	○	○	○				○	○	○	○	○	○	○	○
3	100 (TWT)	84.1	33.1	1	64.1	64.0				○								○	○	○	○	○	○	○	○
				2	70.1	69.9				○	○	○						○	○	○	○	○	○	○	○
				3	78.5	77.4				○	○	○	○	○	○			○	○	○	○	○	○	○	○
				5	83.0	80.5				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
				10	89.0	82.8			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
5	300 (TWT)	93.3	37.0	1	68.0	67.9				○	○	○						○	○	○	○	○	○	○	○
				2	74.0	73.9				○	○	○	○	○				○	○	○	○	○	○	○	○
				3	82.4	82.0			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
				5	86.9	86.0			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
				10	92.9	90.0		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
10	300 (TWT)	99.3	37.0	1	68.0	67.9				○	○	○						○	○	○	○	○	○	○	○
				2	74.0	73.9				○	○	○	○	○				○	○	○	○	○	○	○	○
				3	82.4	82.3			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
				5	86.9	86.6			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
				10	92.9	92.0	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Table 3

○ = Available

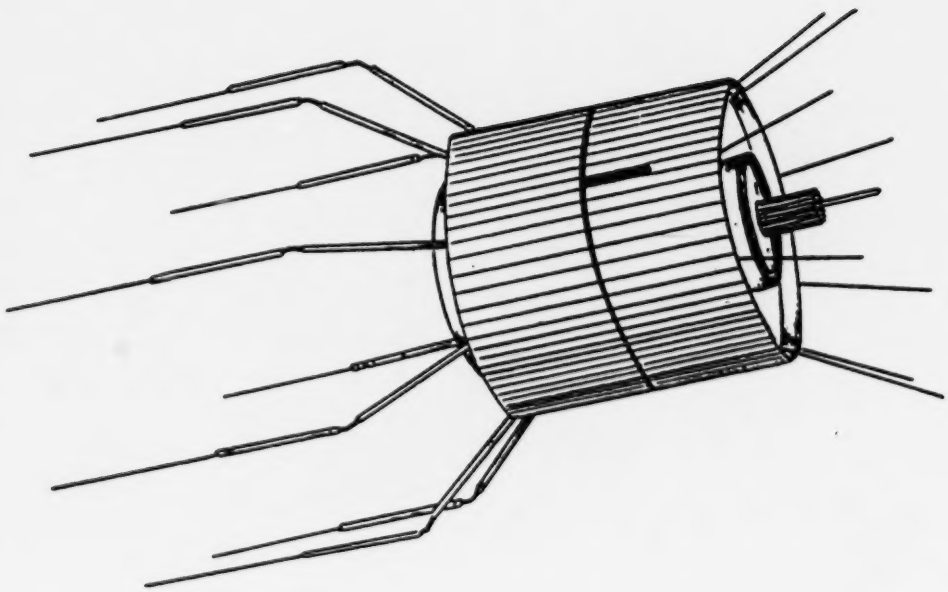


Fig 12 ATS-1 Satellite

NASA's experiments with ATS-1 were more or less completed by 1969. At that juncture NASA made the very important decision of allowing - the Department of Defense in USA, private companies and educational institutions to plan and execute their own experiments for the ATS-1 program. This opened up the possibility of accessing a satellite to many organisations including educational institutions. Many institutions responded to the offer and joined this ATS-1 project. They constructed their own information networks and performed various kinds of activities pertaining to the exchange of voice data and slow speed digital data.

It is worth mentioning that the educational institutions could carry out an entirely new type of activities through the satellite for the first time and that their use of the ATS-1 has given us the prototype of an academic information exchange network.

Many small countries and islands are scatterred in the Pacific region. The physical access between these islands is not very smooth and easy. It is very important for the national and social integration of this region to establish an easily accessible channel of communication . The ATS-1 networks have been fairly successful in this region mainly owing to the fact that educational institutions could have their own earth stations and could access the ATS-1 satellite freely.

The ATS-1 satellite has two kinds of transponders, one uses the C-Band (up-link 6 GHz , down-link 4GHz) and the other uses VHF(Very High Frequency) transmission. The ATS-1 VHF transmission has proved a very attractive communication media for social and educational activities. As the VHF related technology is well established, users of ATS-1 can easily design and setup their own earth stations at a relatively low cost . The ATS-1 was initially located somewhere near the center of the Pacific basin and its area of coverage included the whole of the Pacific region.

In 1981, NASA planned to relocate ATS-1 on the equator at 162 E, because ATS-1 was consuming its station keeping fuel so rapidly that it was expected to go out of

service by the end of 1983. After the repositioning, South-East Asia, the Far East, China and Oceania were brought into ATS-1's area of coverage

The new position of ATS-1 was the gravity hill and it was expected that the satellite will hold its position until, atleast, 1993. But unfortunately, ATS-1 failed to respond commands to hold its position on the gravity hill in 1984. It is now drifting Eastward and its important services in and around the Pacific basin will soon be terminated.

*7.1 Electrical Communication Capability of ATS-1

Some figures on the ATS-1 VHF transmission are listed below-

-EIRP(Equivalent Isotropic Radiated Power)	48dBm
-Received Noise Figure	4.0dB
-Receiving Frequency (up-link)	135.60MHz
-Transponder Band width (20KHz 5 channels)	100KHz
-Transmitting Frequency (down link)	149.22MHz

Characteristics of the ATS-1 transponder

The transmitter of ATS-1 may be operated in two modes . One is the full power mode as is shown above, the other is the half power mode. The output power of ATS-1 depends on the EIRP of the earth station; the output of the satellite is proportional to the EIRP of the earth station, but it reaches saturation at large EIRPs. An earth station of 62dBm (output power 100Watts and antenna gain 12 dB) is enough to saturate the ATS-1 transmitter. Under saturation conditions it is possible for the earth station to catch ATS-1 signals by using receiving systems of 10 - 15 dB antenna gain.

According to NASA's report, VHF transponders of ATS-1 show significant signal compression characteristics *i.e.* when more than two signals are received simultaneously the weaker signal is compressed by the stronger one . This makes

it difficult to receive the weaker signal at earth stations. Moreover, strong intermodulation is observed when two strong signals are inputted to ATS-1 . These are some of the very significant constraints in ATS-1 communication *e.g.* it may be said that simultaneous use of the ATS-1 by more than one application is not practical.

Spin modulation

ATS-1 has the spin stabilisation for altitude control and the spin rate is about 93rpm. In order to compensate for the rotation of the antenna pattern caused by the spin, the despun system, where the phase of antennas are adjusted electrically, is used. Because of the imperfection of the despun system, the received signal level at the earth station is amplitude modulated. This is called the spin modulation. The typical signal level variation due to spin modulation is approximately 2 to 3 dB, but it has been observed, at times, to be much higher. The spin modulation exerts a bad influence upon communication with low signal to noise power ratio.

Fading

The received signal level of ATS-1 VHF transmission sometimes changes with respect to time. This is called fading. There are many ionospheric factors which result in the fading of ATS-1 channels *e.g.* Faraday Rotation, ducting, scintillation etc. These are important factors to be considered in the design of a communication link, particularly in the case of earth stations that are in the border areas of the satellite coverage.

Influence of man-made radio noise

There are many radio communication channels which use the VHF band. The influence of this man-made radio noise is very severe for VHF communication. As the received satellite signal level is extremely weak, the influence of the man-made radio noise is far from negligible. Especially in the case of data transmission, the impulsive noise has a terrible influence on data quality. This results in very bad bit error rates even with a high carrier to noise power ratio. More effective error control methods are expected.

ATS-1 VHF communication

With reference to the above mentioned factors on ATS-1 VHF transmission the following may be noted-

(1) Though the ATS-1 transponder has a 100KHz frequency band, it may be difficult to share this band for simultaneous usage.

(2) One voice channel or slow speed data transmission is a practical possibility. For voice communication there are no major problems except for the dips in signal levels due to fading. In the case of slow data transmission, the effect of the impulsive radio noise in the cities is very severe . Thus efficient data transmission is not expected. But fax and documents transmission that allow manual error correction may find practical and powerful communication media in the ATS-1 VHF transmissions.

7.2 Information Exchange for Educational Purposes with the Wide-area Coverage Satellite ATS-1

It is desirable that educational and research institutions have their own communication network to support their own activities. But it is very expensive to develop and maintain a wired network over a wide area or to use the means of commercial satellite communication because of low traffic characteristics.Thus the necessity of a new low-cost, wide-coverage communication media was being felt. The ATS-1 VHF transmission indeed satisfies these conditions. A voice channel, slow speed fax and documents transmission are available. ATS-1 VHF transmission supported an entirely new style of operation for educational purposes. The possibilities that were opened by this satellite networkmay be listed as follows-

(1) international open classroom,

(2) sharing of academic information,

(3) education for staff of educational institutions,

(4) education in sparsely populated areas,

(5) collection of scientific information scattered over the globe,

(6) collection of observed data on natural phenomena,

(7) local cultural exchange,

(8) spread of scientific techniques,

(9) medical services,

(10) international conferences,

(11) international seminars,

(12) electronic mail service, etc.

It is notable that even small-size educational institutions can share in the benefit by setting up small earth stations.

Outlines of the some representative ATS-1 educational-purpose networks .

7.2.1 PEACESAT network.

PEACESAT (Pan-Pacific Education and communication Experiments by Satellite) was organised by Dr. John Bysctrom at University of Hawaii , Manoa in 1971. Dr. Bysctrom was planning to carry out local-distance education and other related activities for the Pacific region. In this region, the conventional communication posed some difficulty. Moreover, terminals at Pacific islands had to be made available at a low cost. NASA's decision to allow the usage of the ATS-1 satellite for educational purposes did sound very attractive to Dr. Bysctrom and he applied for and obtained the permission to use the ATS-1.

The stated purpose of the PEACESAT was "to demonstrate the benefits of currently available telecommunication technology when applied specifically to the needs of sparsely populated less industrialised areas". At the beginning of the PEACESAT project, only three terminals set at Hawaii were connected to the network. Nevertheless that was the first satellite communication network for educational purposes, in the world. In 1972 , Wellington Polytechnic of New Zealand joined this project and the network became an international one. After that many countries joined this network, having set up their own ATS-1 earth

stations. In 1981 the satellite network covering 18 Pacific island nations was established. PEACESAT was the experimental network designed for tele-conferences through voice communication. Hundreds of experiments and demonstrations in communications have been carried out amply demonstrating the benefits of a satellite communication network in the Pacific region.

PEACESAT was allotted its own ATS-1 time-30 hours per week.This time was used for- education, health services , community development, scientific research, international conferences, emergency communication and cultural exchanges. The items covered in the tele-conferences for the educational activities were as follows-

- Computer experiments	weekly
- News exchange	weekly
- Building engineers	every alternate week
- Renewable energy	monthly
- Medical engineering	occassional
- Primary school exchange	occassional
-High school exchange	occassional
- etcetera.	

The alloted-time-utilisation factor ((the ratio of available time to the time actually used)/1000) was 72.5. This indicates that PEACESAT was a fairly active network. PEACESAT has been active as a non-profit network in the Pacific area for 18 years and has demonstrated its capabilities as a prototype of a satellite academic information network among educational educational institutions.

7.2.2 The USP network

In response to a letter of invitation from PEACESAT, the University of the South-Pacific (USP) in Suva, Fiji, joined the PEACESAT project in 1972. The USP' s ATS-1 station was initially set up at the main campus in Fiji. As the USP gained

success in the educational activities with a satellite, many USP terminals were set up and USP's own network was established in 1974. The objectives of the USP network were as follows-

- Identify effectiveness of the uses of an audio link,
- Establish distant classrooms for external studies,
- Support continuing education programs via tele-conferencing,
- Conduct joint curriculum planning and development,
- Provide rapid exchange of administration information.

The system was used for teleconferences to support governmental and community activities among nine member nations, but most of the time was devoted to external studies. In 1981, the USP network supported 46 courses enrolling nearly 2000 students. The USP network was alloted ATS-1 time for 20 hours per week and it has achieved very good results in connecting nine regional centers for educational activities.

7.2.3 PACNET.

A satellite link is a very attractive idea in making in developing a computer network among universities. The university of Hawaii used the ARS-1 VHF transmission to extend the ALOHA network to the Pacific area. The ALOHA (Additive Links On-line Hawaii Area) is constructed by connecting the terminals at the different branch schools of the University of Hawaii, scattered over the Hawaiian Islands, to the large computer located in the main campus. Tohoku University located at the east edge of ATS-1 coverage had recognised the importance of a satellite-based international computer network for future academic activities and planned to join the ALOHA network by establishing a link between Hawaii and Tohoku, in 1972. In 1974, the Pacific area Academic Computer Network (PACNET) working group was formed with the University of Hawaii , the University of Sydney , Tohoku University and other interested organizations. The aim of PACNET was to investigate the use of a computer

network for promotion of joint educational and research activities among other universities through the ATS-1 VHF transponder. The system diagram of Tohoku University PACNET earth station is shown in fig. 13.

A point worth mentioning is that these VHF transmission systems are low-cost and easily maintained. Further, as the width of the antenna beam is quite wide - accurate satellite tracking is not required. Thus educational institutions, with their limited means, do really have a chance of carrying out satellite communication experiments.

Computer messages are sent in packets. A data packet is formed with a header , a header parity, a text and a text parity. To realise a satellite computer network, it is necessary to investigate the characteristics of a data link. Tohoku University carried out various data transmission experiments with the cooperation of the University of Hawaii and the University of Sydney. Some results of these experiments are shown in the figs 14a and 14b. Fig. 14a shows the observed bit error rate for a continuous data stream and fig. 14b shows the observed packet error rate. Both figures show that the ATS-1 radio link is quite noisy. The physical level protocol details of this experiment are as follows-

-Modulation VHF FM-modulation
data DPSK (Differential Phase Shift Keying)

- Bit rate 9.6 Kbps

The main reasons behind the poor quality of the link are-

(1) the influence of man-made radio noise in cities (the impulsive noise),

(2) the received signal level is not always steady because of fading.

More powerful error control methods for burst radio noise were applied experimentally. By using these techniques the average bit error rate was improved but it became clear that the effect of impulsive radio noise was severe for packet detection rate in the VHF band. But experiments on computer communication could be achieved when the satellite link was steady by using the ACK/NAK method. An example of this experiment is shown in fig. 15. In this experiment a

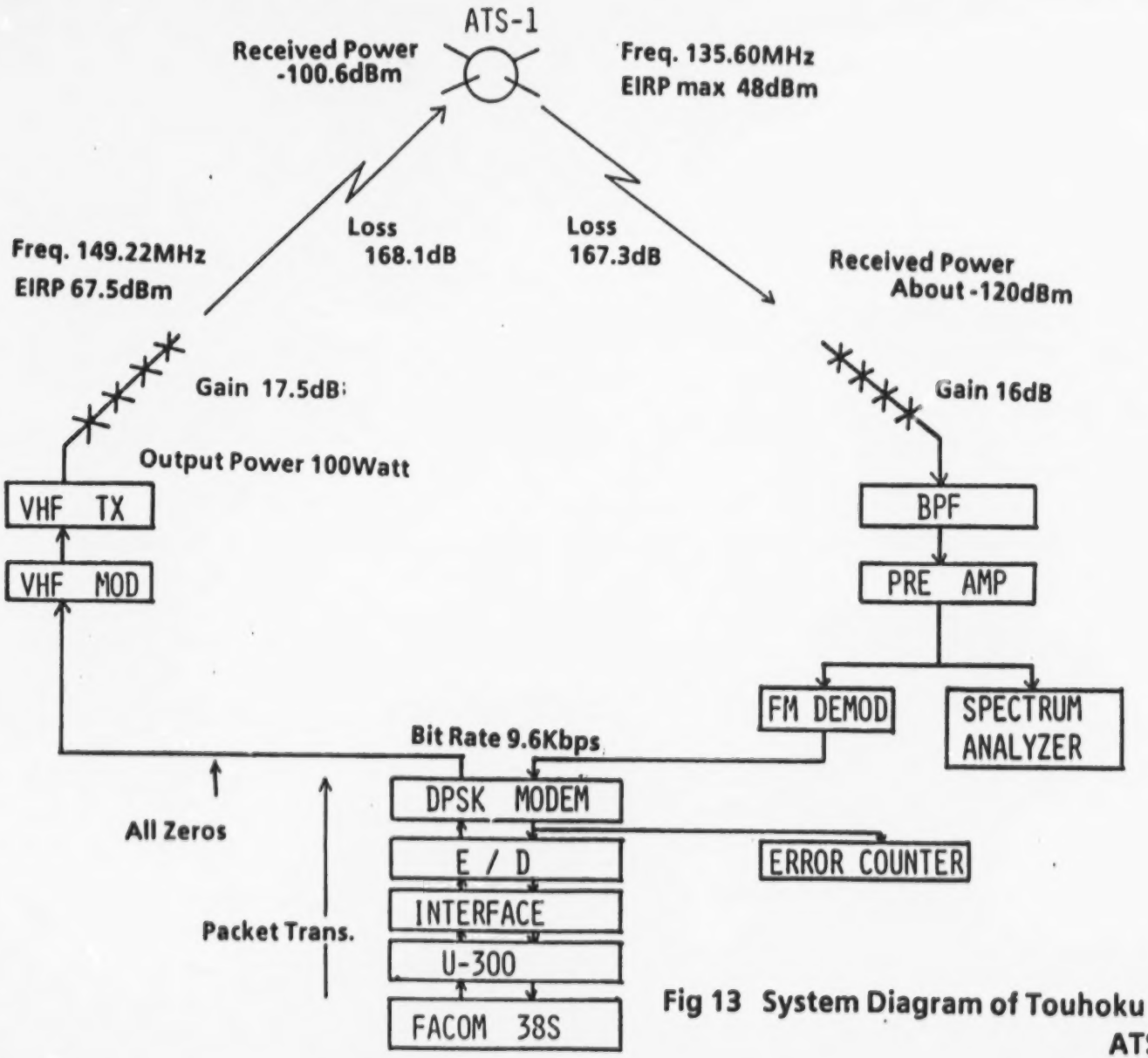


Fig 13 System Diagram of Touhoku University ATS-1 Earth Station

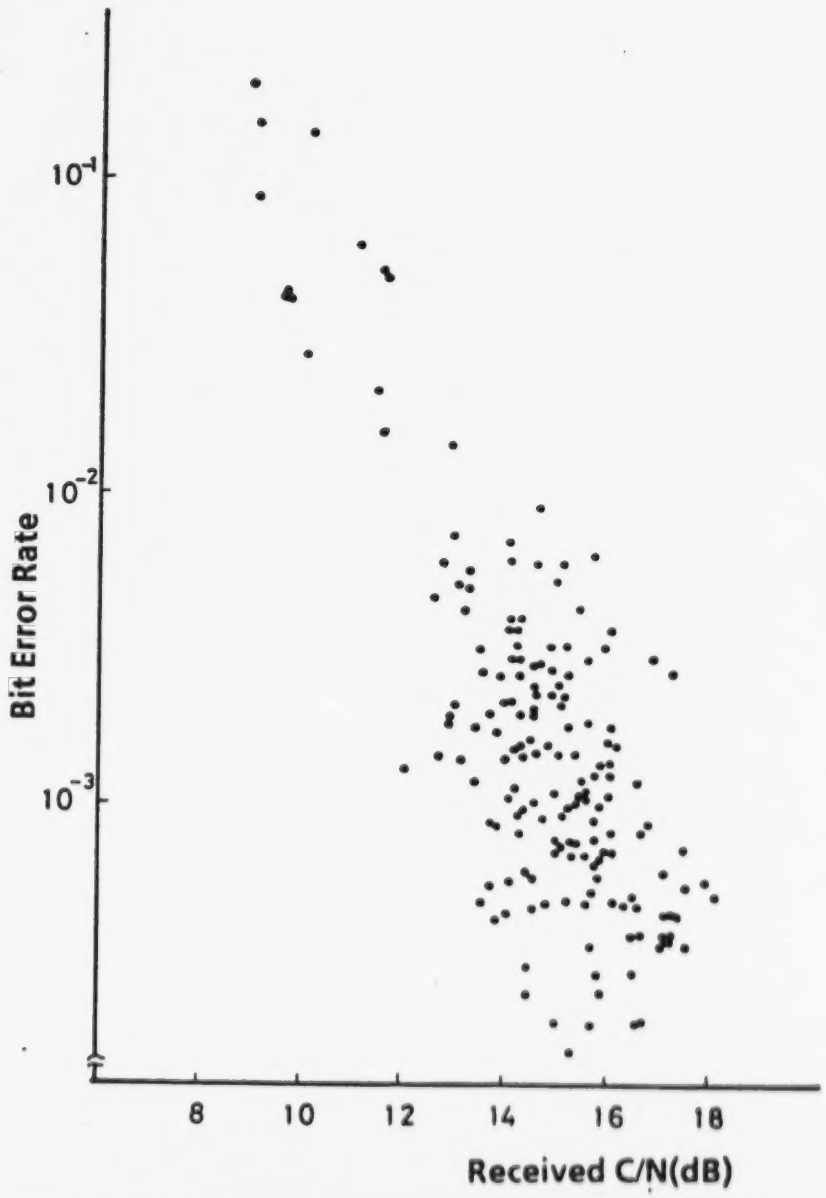


Fig 14-a The Relation Between the Error Rate of the Zero Stream and the Received C/N

DATE			March 23	March 24	March 25	March 26
C/N (dB) RECEIVED POWER (dBm)			11～20 −106～−113	16～20 −106～−109	16～20 −107～−108	20 −107
ZERO STREAM	ERROR RATE	AVERAGE MAXIMUM MINIMUM	7.13×10^{-4} 2.36×10^{-3} 3.10×10^{-6}	1.06×10^{-3} 3.49×10^{-3} 3.30×10^{-4}	9.39×10^{-4} 1.84×10^{-3} 1.17×10^{-4}	1.84×10^{-3} 3.66×10^{-3} 6.25×10^{-4}
PACKETS	TOTAL		466	459	453	714
	ORIGINAL	NO ERROR 2 BITS ERROR 4 6 8 10 10↑	331(71.0%) 84(18.0%) 16 8 1 0 7	327(71.3%) 91(19.8%) 21 9 1 1 6	341(75.4%) 71(15.4%) 15 8 5 1 3	462(64.7%) 143(30.7%) 45 17 15 3 16
	ECC	NO ERROR 2 BITS ERROR	411(88.2%) 4	379(82.6%) 39	370(81.9%) 42	600(84.0%) 4
	BIT ERROR RATE	ORIGINAL ECC	2.24×10^{-3} 1.60×10^{-3}	2.00×10^{-3} 1.59×10^{-3}	1.44×10^{-3} 1.31×10^{-3}	2.43×10^{-3} 1.72×10^{-3}

Fig 14-b Results of Test Packet Reception
(Touhoku — ATS-1 — Touhoku)

```
                                                                                Seq.
C       FORTRAN PROGRAM FROM HAWAII 22/8/77.....                        0000     1
C       HERON'S FORMULA.....                                            0000     2
      READ(5,100) A1,A2,A3.....                                         0000     3
  100 FORMAT(3F12.5).....                                               0000     4
      CALL HERON(A1,A2,A3,S).....                                       0000     5
      WRITE(6,101) S.....                                               0000     6
  101 FORMAT(1HO,F12.5).....                                            0000     7
      STOP.....                                                         0000     8
      END.....                                                          0000     9
C.....                                                                  0000    10
*       PROCEDURE HERON FORMULA.....                                    758C    11
C       PROCEDURE HERON FORMULA.....                                    0000    12
      SUBROUTINE HERON(A,B,C,AREA).....                                 0000    13
      S=(A+B+C)/2.0.....                                                0000    14
      AREA=SQRT(S*(S-A)*(S-B)*(S-C)).....                               0000    15
      RETURN.....                                                       0000    16
      END.....                                                          0000    17
         3.0          4.0          5.0.....                           0000    18
```

(a) The FORTRAN program sent from the University of Hawaii

```
                                                Seq.
6.                                               1
PF 0000 F600   152                               2
PF 0000 0000     0 6.                            3
```

(b) The answer for the program sent back from Tohoku University

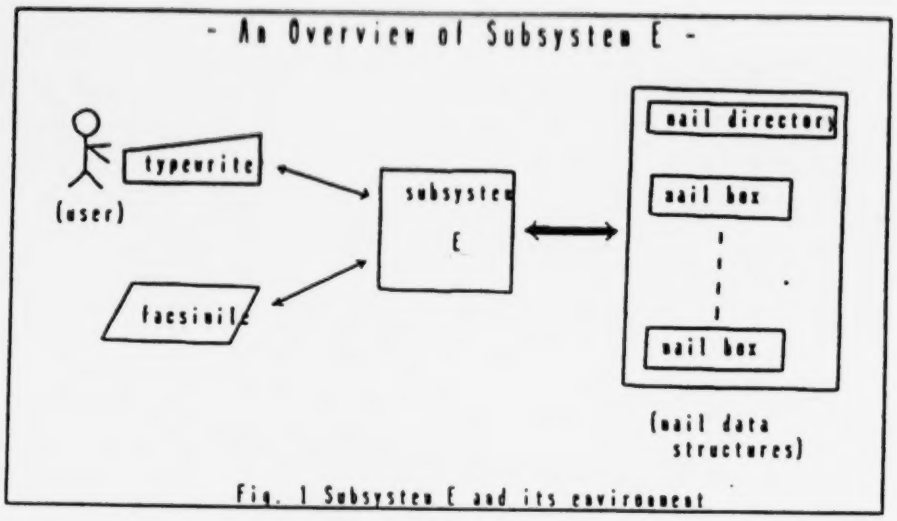
Fig 15 An Experimental Result of the Remote Job Entry

FORTRAN program was sent by the University of Hawaii in packets. Tohoku University sent back an affirmative reply (ACK) or a negative reply (NAK) for each packet.

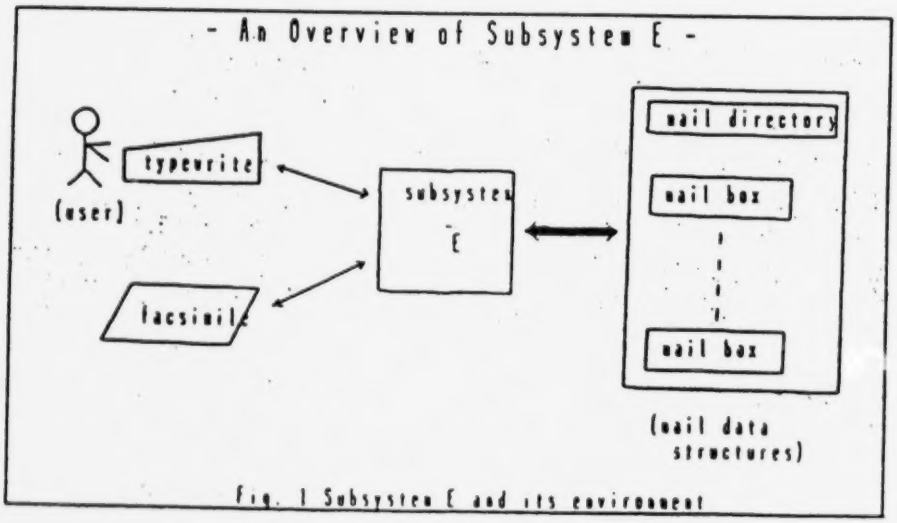
Although simple computer communication via ATS-1 was fairly successful , it seemed to be quite difficult to make a proctical computer network with ATS-1. But experiments showed that the satellite link is a very powerful and attractive implement in the development of a global academic network aimed at using computer facilities located at various places.

7.2.4 Asian and Oceanian Academic Information Exchange Network Plan.

The repositioning of the ATS-1 to westward of 162 E made it possible to access ATS-1 from China and South-East Asia . The construction of an Asian - Oceanian academic information network linking the universities in these regions became a feasible idea for the frst time. Various long term experiments have shown that the ATS-1 radio link is very powerful for voice tele-conferences. Slow speed Fax and document transmission may become applicable for this new academic information network. For example, results of experiment on Fax and document transmission at the Tohoku University's closed ATS-1-loop is shown in figs 16a. and 16b. Considering the low cost of earth stations and wide coverage of the ATS-1 network, it may be said that the academic information network for Asian and Oceanian regions via the ATS-1 network is very powerful to support and promote future international educational activities. In 1984, the cooperative research project between Tohoku University and King Mongkut's Institute of Technology, Bangkok, Thailand was started as the first stage of construction of Asian and Oceanian information network among universities. But unfortunately, ATS-1 has moved away eastward.



Original



Recieved Result of Slow Speed Fax Transmission
(Touhoku—ATS-1—Touhoku)

Fig 16-a Experimental Result of Slow Speed Fax Transmmision

Document Transmission

NS	CAN AN OUTPUT CODE BE ASSOCIATED WITH IT?	RETURN VALUE OF SEND OR RECEIVE CHECK	ACTION IN CALL
N	YES	FALSE	CHANGE TO INDICATED STATE

Original **FSK 600 Baud**

Received Result

NS	CAN AN OUTPUT CODE BE ASSOCIATED WITH IT?	RETURN VALUE OF SEND OR RECEIVE CHECK	ACTION IN CALL
N	YES	FALSE	CHANGE TO INDICATED STATE

NS	CAN AN OUTPUT CODE BE ASSOCIATED WITH IT?	RETURN VALUE OF SEND OR RECEIVE CHECK	ACTION IN CALL
N	YES	FALSE	CHANGE TO INDICATED STATE

Fig 16-b Experimental Result of Document Transmisson

7.3 Impact of ATS-1 networks

Although the communication capability was fairly limited and the data capability was not very good, communication networks with ATS-1 have given a strong boost to the construction of academic networks among universities. Many educational organisations could have their own earth stations and carry out their own activities through the satellite because of the low cost of the earth station and the free satellite access. Further ATS-1 had a very wide coverage and this made it possible to adopt a new style of academic activities. It may be said that the ATS-1 network is one of the prototypes of future information exchange networks among universities. If universities have a chance to utilise a more advanced C, or K-band satellite as an alternative to the ATS-1 , the new satellite link may become a high quality multi-communication media and universities will obtain a powerful implement to further academic interests in the same way as ATS-1 networks were used.

[8] THE FUTURE TRENDS IN SATELLITE COMMUNICATION.

8.1 Future Satellite System.

It is certain that the satellite communication will assume a much more powerful role in the coming age and will drastically change the scene in education ,business communication and many other fields. The current trend indicates that, small systems for direct broadcasting applications will continue to grow and there will be hundreds of millions of small terminals in use. Also, the price of such terminals will reduce remarkably. This situation will us give an excellent opportunity to utilise satellite communication in many fields of our future life including research and education.

Next, we take a look at the type of satellite system that may be used. The satellites systems for communication applications may be categorised into following categories based on their operational frequency band -

- Satellite systems working in the VHF and UHF ranges,

- Satellite systems working in the 2GHz - 15GHz range, and,

- Satellite systems working in the above-15GHz range.

The satellite systems working in the VHF and UHF ranges are of small scale and will find use in the wide area direct broadcasting and small data transmission and collection services. The most remarkable points of this system are - the ground station is small but cheap, resulting in many stations. The transmitter of these ground stations have an output of a few hundred watts and a small antenna system. This system will support the new kinds of applications in communication of the wide area service as was given by ATS-1 .

The systems belonging to the second category, are of two types-

(a) medium size systems , and ,

(b) large size systems.

the medium size systems serves the low capacity multi access international and domestic communications with a capacity of roughly 10,000 telephone lines (bilateral). The transmitter of this ground station will have the output of 1-2 KW. The antenna system will have the aperture of upto 10m.

The large size systems will serve the large capacity point to point communication for both international and domestic purposes. We can expect a channel capacity of 100,000 channels of telephones (bilateral) and several TV channels - all this by using a satellite of the 3-Ton category. The transmitter of the ground station will have the output of around 10KW and the antenna will have an aperture of 30m.

The third category of systems has been developed mainly in Japan and the practical usage of this system is being demonstrated by promoting the CS- project. Thus far the results have been good. The next satellite CS-3 will be launched in 1988. This satellite has a weight of 0.3 tons . It is expected to offer a channel capacity of 12,000 lines.TDMA with 60Mbps data transmission will be available using ground stations with antennas of 10m aperture. The remarkable characteristics of this system is the utilisation of the multi-beam antenna system which is completely different from the usual single-beam ones. The main feature of

this multi-beam satellite system is

- large information communication capability using small ground stations.
- high utility of satellite channels by assigning individual frequencies to each beam.

This means many stations can access the satellite system simultaneously for their individual communication purposes. This technology is now under development. We are expecting transmitters of higher power capable of data transmission at higher speeds, in the near future. Many countries are now promoting the use of this frequency band concept in satellite communication.

8.2 Some new technology in satellite communication.

In the present stage of satellite communication, the system operates as a communication channel without any added information procesing capability . But there will be a drastic change in the concept of data transmission by satellite communication in the future. We can setup large data processing capabilities on the satellite and expect the new operation of on-board data-processing by the satellite. This technology will play a very important role in many fields of communication in the coming age. One example would be the solution of the interference problem between satellites.

[9] CONCLUSION

In this report, we have discussed the type of worldwide infrastructure that should be constructed for all peoples in the highly advanced information society.This worldwide information network system will promote not only information exchange but also mutual understanding among citizens of this world.

We have also stressed that this information network will play a very important

role in the field of research and education in the coming new age. After examining the various options and the given circumstances we have concluded that the satellite information system system combined with the terrestrial system is the most efficient system for such purposes. We have then briefly described the concept and the design methodology of the satellite network system. The functioning of some existing satellite network systems e.g. ATS-1 , PACNET have been examined to confirm the efficacy of the proposed network system for university education and research. From the concrete data available on these experimental networks we can strongly affirm that a satellite information network is not just an important tool for research and education, but it will also provide us with an important implement for the promotion of understanding among the peoples of the world.

From this standpoint, we should promote the construction of the worldwide satelite network system as early as possible with the cooperation of all countries and that of UNESCO.

Acknowledgement: We would like to express our sincere thanks to Mr. Glenn Mansfield for going through the manuscript and helping us in making a better presentation of the material.

[1] Y.Kitahara, "Information Network System", The Telecommunication Association,1982

[2] NASA, "ATS-1 VHF Experiments' Guide", ATS Project, Goddard Space Flight Center, Greenbelt, Maryland, Feb., 1971

[3] N.Abramson, "The ALOHA SYSTEM" Technical Report B72-1, University of Hawaii Jan.,1972

[4] J.Lange et al.,"ATS-1:Social Service Satellite Networks in the Pacific", Proceeding of PTC'84,pp109-118, 1984

[5] R.Sato et al.,"Data Transmission Utilizing the Application Technology Satellite ATS-1(1),(2),(3)",The Technology Report of the Tohoku University, vol.40,No.2,pp247-272,Dec.,1975;vol.41,No.2,pp151-169,Dec.,1976;vol.43, No.2,pp433-441,Dec.,1978

[6] R.Sato et al."An effective Packet Transmission in Noisy Channel Using ATS-1", The Technology Report of the Tohoku University,vol.47No.1,pp1-8, Jan.,1982

[7] D.C.W.Phipps,"PACNET Experiments in Digital Communication via the ATS-1 VHF Satellite Channel",Master Thesis,University of Sydney,Nov., 1982

[8] RRL(Japan),"Examples of Design of Satellite channels for CS-class satellite"

[9] K.Miya,"Satellite Communication Technology" Corona-sha,Tokyo,Japan, 1980

[10] T.Muratani,"Expansion of International Communication", Joint Meeting of Electrical Institutions of Japan,25-3,1985

Section III

Kyril B. SERAFIMOV

The Impact of Satellite Technology on University Teaching and Research

THE IMPACT OF SATELLITE TECHNOLOGY ON UNIVERSITY TEACHING AND RESEARCH

Kyril B. Serafimov*

1. INTRODUCTION - THE SPACE AGE AND EDUCATION: BASIC INFORMATION ON SATELLITES AND EDUCATION

The space age has become a source of progress for society at large. It has stimulated industrial and socio-economic development and is a major component in today's scientific and technological revolution. Even in the field of education, it is now widely recognized that the launching of "Sputnik 1" marked the beginning of a genuine revolution in the USSR, the USA and other countries. The attitude towards what constitutes the educational process changed abruptly and the perceived need for education became more widespread, as the belief in man's creative potential was strengthened. There was a call for a new and powerful development of education at all levels, from pre-school to postgraduate.

A network of satellite communications was quickly established, bringing with it a whole set of radically new tools to disseminate knowledge, that set the stage for revolutionary innovations, both direct and indirect, in university activities. Among the new factors that are relevant to university training, the following are of particular importance:

1) satellite facilities constitute an advanced base for the acquisition, transmission and processing of all types of data, thereby providing a great boost to university research;

2) in the near future, satellites will become the backbone of reliable modern information systems that can directly assist university activities;

3) university staff are actively involved in the investigation and use of outer space;

4) thanks to space research, universities have obtained new training and research subjects; significant new financial and technological possibilities to expand academic participation in basic space research and its practical applications; significant psychological and other stimuli,

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thanks to the successful involvement of university staff in space projects.

For all these reasons, the problem has captured the attention of the international community. A series of recommendations was made, for example, in a Report to UNISPACE-82 (3). These recommendations were endorsed by the UN General Assembly (Resolution 37/90). The Committee on the Peaceful Uses of Outer Space (COPUOS) and its Scientific and Technical Committee at their 1983 Meeting examined the question of the implementation of these recommendations and recommended that three studies, including one on the feasibility of direct broadcasting satellites for educational purposes and of internationally or regionally owned space segments, be given priority. These recommendations were endorsed by the General Assembly (Resolution 38/80). The Committee recommended that this study be carried out in co-operation with the International Telecommunication Union (ITU) and with the United Nations Educational, Scientific and Cultural Organization (UNESCO).

1.1. Expanding the Educational Content with Space-Oriented Subjects

Since ITU is primarily concerned with the technical aspects of this problem, it is up to Unesco, in our opinion, to resolve conceptual problems; to develop systems for satellite applications in university training; to support the development of a new pedagogy that incorporates means of disseminating knowledge and scientific information through satellites, new academic training methods as well as methods to transmit academic knowledge and scientific achievements to society at large. Of specific concern to Unesco are problems of the interrelation between university training staffs and specialists involved in satellite communications and training systems, as well as problems of international co-operation in the development of satellite educational systems.

A mere 25 years ago, astronomy was considered the only space-oriented subject. Today, courses in space-related subjects cover just about every scientific field, which corresponds to the space-orientation of contemporary knowledge (1). Many universities offer separate instruction in astronautics, and astronautic knowledge is also taught in various courses in physics, mechanics and the like. Satellite telecommunications is a separate discipline in many technical universities and high schools (for example, at the V.I. Lenin Higher Mechano-Electrotechnical Institute in Sofia). Many university programmes include courses on space biology, and in almost all geology and geography departments there are courses on remote sensing. This list is not complete without a mention of jet-propulsion, low gravity technologies, spacecraft

mechanics, astrodynamics (natural and artificial motion), space physics, space radioelectronics, space psychology, space law, and the history of space flights, among others.

A similar process of expansion of subjects taught thanks to space activities can be observed in primary and secondary schools. What is more, space subjects dominate extra-curricular activities, as we shall see in a moment.

Of course, space disciplines are integrated differently from one country to the next. Lectures on the design and development of scientific instruments in space, for example, provoke particular interest in Dallas and Sofia, while in Maputo or Ulan-Bator they are of little practical importance. While remote sensing techniques are taught just about everywhere, courses on the gamut of space activities are seldom set up. This is indeed unfortunate. A number of publications (2 to 5) is devoted to the problems involved in determining what type of space subjects should be included in university curricula, and what subjects should be reserved for exceptionally serious students. That is why we shall not explore the question here.

1.2. The Use of Satellites for Retransmission of Educational Programmes

We shall briefly examine the use of satellites as a means to transmit educational programmes, with the possibility of feedback between the lecturer and students. The experiments conducted to use specialized educational satellites in primary and extra-curricular knowledge dissemination are well known (2, 3, 5 to 18). One famous experiment was made in the USA with satellites of the ATS series (ATS-6) transmitting educational programmes. The same satellite, in a different location, was used in India for the experimental system SITE (3,7,19). More than 2,400 villages, which were provided with small receiving antennas measuring 3 metres in diameter and electronic converters and amplifiers, were thus covered. The total cost of the electronic equipment was about two times more than for normal television sets. At noon, there were educational broadcasts for children aged 5 to 12, and in the evening, there were programmes for adults. Since 1964, experimental educational broadcasts have been done in the USSR, and since 1965, Molniya-1 satellites have been used, supplemented today by Raduga satellites (Statsionar) as well as by the latest satellite Ekran. Ekran satellites have enough power to be used in simple and efficient group ground-based stations. In many regions of the USSR, Finland and Norway, these satellites can receive direct TV broadcasts. The Canadian Telesat system uses

AHUK-A satellites with 80 ground stations. The STS satellite was used in Canada specifically for direct TV and radio broadcasts within the range of 12 GHz, and educational programmes and medical consultations alike were made possible. The ATS-6 has been used in the USA for similar purposes: medical personnel in Alaska have been able to consult with professors at Washington University. Moreover, 1,200 teachers in secondary schools in the Appalachian Mountains and 15,000 students in the Rocky Mountain region also got direct assistance from qualified professors at various US universities in this way.

It is clear then that from pre-school to post-graduate levels, university staff as well as laboratories, observatories, and other academic centres can play an important role, through satellites, and can now reach a vast audience.

Today, the ANIK-B satellite, which works in the range of 12/14 GHz, is used in Canada for direct TV broadcasting, and it holds out major hopes for direct satellite applications in education. Joint experimental work on direct TV broadcasting of educational programmes and scientific and technical data transmission is being carried out within the framework of the INTERCOSMOS programme. In particular, joint experiments are being made at the test site of Dubna with equipment using frequencies above 18 GHz. Some experiments on satellite retransmission of educational programmes by direct receiving from the user were carried out in Peru, Labrador, Australia, Brazil, and by ESA (Western Europe) and other countries.

Without attempting to give a complete review of all that has been done so far in primary and secondary schools (see 2,3 and 6 through 19), the following list gives an idea of the technical possibilities for satellite retransmissions for educational purposes.

1) Radio and TV satellite transmission using group ground-based stations.

2) Direct TV (video and acoustic) retransmissions by direct receiving with convenient receivers.

3) Direct TV communication with bilateral audio-coupling.

4) Direct TV communication with bilateral audio-visual coupling.

5) Bilateral audiocoupling only.

6) Slow sweep TV with or without bilateral communication.

7) Textual retransmission through a TV system.

8) Phototelegraphy.

9) Computer access for training purposes.

To give an idea of what has been achieved with these new tools, mention should be made of the following experiments. Experimental broadcasts of lectures were made in India using ATS-6, Symphonie, Apple, Insat-1A and other satellites. In Canada, tele-educational experiments, including Hermes broadcasting experiments (1979), were undertaken in conjunction with university professors. Within the framework of these experiments, the following was done specifically for university purposes.

1) Curriculum sharing: an exchange of courses between Stanford University in Palo Alto, California, and Carlton University in Ottawa, Ontario. Two-way television and voice channels were set up, enabling simultaneous student participation in the respective classrooms. Students generally considered the experiment satisfactory, though they felt that face-to-face access to the lecturer was more desirable. (This reaction will be examined in further detail).

2) A university omnibus network was conducted by the University of Quebec which linked six universities and seven institutes situated 1,300 kilometres apart. A dozen projects, including scientific research, community interaction, tele-teaching, professional training for teaching staff, were carried out.

3) Learning centres were organized for various educational purposes, from the primary to the post-graduate level, and for knowledge dissemination among the population covering such fields as medicine, agriculture, politics, and culture, among others.

In 1979, a TV university was set up in China in order to raise the cultural and scientific level of the population. Audio-visual broadcasts produced by the university and transmitted by satellite were expected to begin in 1985. In 1982, some 78,000 students (workers, teachers, technicians, governmental employees, etc.) graduated through television courses. The Chinese are counting heavily on direct TV broadcasts, in particular in the fields of mechanical engineering, electronics, and the like.

In the USSR, students in remote eastern and northern regions are able to listen to lectures and watch exercises by eminent professors in Moscow, Kiev and Leningrad. Using standard telephone lines (and at times satellite retransmission) feedback was also established. A main editorial office for popular science and educational programmes by television, was set up in 1970; it uses regular TV channels as well as Vostok and Orbita satellites. Each year special broadcasts for university candidates are organized to assist them in their examinations. Particular attention is paid to physics and mathematics and the "TV Physico-mathematical School" was set up. It works on the feedback principle; trainees are provided with home work and

tests and they answer by mail and sometimes by phone. A major part of these broadcasts is devoted to general courses in university studies, from the first through the third year. The most promising results were obtained with students who, despite full-time jobs, completed correspondence courses, using the feedback system. Post-graduate lecture courses are also transmitted, in particular, to improve economic planning and management, as well as to ensure post-graduate consultations.

At the University of Florida, technical training by TV has been going on for several years. Post-graduate work, doctoral presentations in the sciences, etc. was carried out within the framework of GENESYS (Graduate Engineering Education System), and later expanded with SUNSTAR (State University System for Television and Radio). The EDUSAT system was developed in 1968. Many African countries use the Symphonie system.

Projects for various stages of primary education and for higher, post-graduate, doctoral qualification and academic knowledge and information dissemination were developed. Since 1967, India, Indonesia, Brazil, Nigeria, Argentina, Peru, among other countries, have reported their progress to the COPUOS and IAF/IAA Congresses.

Indonesia has adopted the PALAPA system, using two geostationary satellites at 83°E and 77°E, that is a group method of receiving educational programmes at earth stations (32), which are re-broadcast by local VHF-TV-transmitters. Direct broadcasting from satellites, including inter-university communications, is foreseen.

The following table gives the number of projects developed for telecommunication satellite usage for educational broadcasts, including academic training (12).

Table 1

Educational Broadcasting Projects Via Communication Satellites (1982)

Country or region	Project
Brazil	1
Canada	17
India	3
Indonesia	1
Philippines	1
USA	12

US/Brazil	1
US/Canada	1
USSR	1
Caribbean: Jamaica, St. Lucia, Barbados	1
Pacific Basin and the South Pacific Region: 11 countries	1
Africa: 12 countries (Symphonie)	1

Satellites used for transmission of scientific and technical data, university research projects and other university information needs are not included here. They will be analysed briefly later on.

As the scientific and technical revolution moves ahead, it is amply clear that the role of universities is expanding rapidly, not only as far as training and research activities are concerned, but also for post-graduate training and doctorates in science to meet the needs of industry, and of the economy, generally, as well as to disseminate advanced knowledge that will increase society's capacity to absorb scientific achievements (20, and particularly 21,22). These new and innovative functions are excellently fulfilled across great distances by communication satellites, used for consultations, lectures, scientific films, data and information transmission, etc. In 1970, according to the International Telecommunication Union (ITU), TV information transmission using space-borne equipment was more efficient for distances over 1,800 km. than retransmission by ground radio-relay or cable lines. Today, the figure has dropped to about 1,300 km. (at 1984 prices), and it is expected to fall to about 300 km. by the end of the century. This means that even for relatively small countries, the use of communication satellites will be more efficient. Science and academic education are being upgraded around the world, which will increase the role of satellite methods for educational programmes, lectures, data and other transmissions.

1.3 Satellite Applications for Broadcasting Popular Science and Cultural Programmes

This problem was partially treated in the previous section, but we should like to emphasize here that communication satellites are already making our planet "one big village" for all types of information, and in particular for scientific and technical information. Though there is still a way to go before we reach the stage of direct TV broadcasting by satellite, hundreds of millions of people have seen, for example, the television series called "Cosmos" by Prof. Carl Sagan, which was retransmitted by ground

stations. Hundreds of other popular science films, lectures by eminent scientists and information on scientific and technical breakthroughs are now being transmitted thanks to the satellite communication bridge that links continents and peoples.

If universities are to develop, it is crucial that they make their activites more widely known. This will condition understanding and respect on the part of society and governments, and will affect the financial and psychological support they will receive. To do this, universities should publicize their educational and scientific activities and also inform people about their internal functioning, their structure, organization and special spirit. The international exchange of such information by communication satellites is already taking place and the role direct TV broadcasts from space can play in the future will significantly contribute to the recognition and further development of university activities.

The role of universities in the dissemination of knowledge concerning the "liberal arts" has already been explored (21) as have the effects of the space age and in particular of communication satellites, for the cultural development of our civilization and its contribution to the evolution of human psychology (23 and 24). The various forms of the university's cultural and social activity has also been examined (25,26).

1.4. Other Applications of Satellites to Educational and Research Activities

Satellite techniques are especially helpful when major events are taking place, for example, a surgical operation, a unique natural phenomenon, or a cultural event. Particularly effective are live broadcasts on scientific, technological and educational events. Among the various methods of conducting tele-conferences that have been evolved (5,21), scientific experiments with student participation hold out significant potential to educate students. They can also help enrich science with new ideas and objectives, that can immediately be incorporated in the creative process of scientific research.

The enormous and steadily growing number of satellite applications to acquire, process, transmit and store data, be it research, educational, observational, iconomic and other information, forms the basis for the development of contemporary science in the academic world. We shall examine these aspects in greater detail.

1.5 Other Major Effects of the Space Age on Education and University Development

1.5.1 The greatest impact of the space age on education can be seen in the growing interest among all of enlightened humanity in science and knowledge. The desire for education has expanded significantly, as has the motivation to innovate the educational process. There is growing respect for education, and this has led to a new creative approach to all stages and forms of education. The greatly increased interest in science, the conviction that it still has immense potential, the determination to explore the endless possibilities for creation can be seen in all the stages of space conquest. The sudden upsurge of interest in education and science will not be discussed here (see 1,3,5,6,14,15,16,18,19,21). The important role of space activities in the expansion and renewed motivation in education is discussed in 3,5 6,14 to 19,21,27 and 28. We have shown that space research and its uses have directly and indirectly generated the Second Educational Revolution that is computer-oriented and that is taking place today (18).

1.5.2. Technology transfer from space activities to education, and vice versa, that is, progress in education that goes to accelerate space activities, is well under way (5). The effects of space-research transfer and its spin-offs can be seen in present day computer-orientation and in audio-visual applications of lecture delivery, and primarily as demonstration and experimental tools of education.

1.5.3. Space activities have contributed significantly to the dynamics of the education process, as regards training subjects, methodology, content, applied techniques, and the like. As we shall see, the role of communication satellites to establish inter-university connections can be used to improve university organization and administration and to strengthen their international relations.

An indirect but important aspect of the space age is the effect on universities of astronautical courses and schools for children and young adults. The positive effects of astronautical societies in the USA or of school groups devoted to satellite observations in Bulgaria (the National Observatory of Stara Zagora) was obvious from the beginning. As early as 1968, the First UN Conference on the Investigation and Peaceful Exploration of Outer Space, held in Vienna, noted that they were helping to form a new generation of creative, science-oriented youngsters. At the National Observatory of Stara Zagora, established in 1960, it is evident that participation in astronautical societies, satellite observation, rocket-models and other space-orientated activities offsets the negative effect of the "street", and helps form culturally active and creative persons. A small number of these children have gone on to work at the

Stara Zagora branch of the Central Laboratory for Space Research, where they have made not insignificant contributions to the Bulgarian space programme (30,31). Most of the others became engineers, physicists and chemists. Some are now working at the Plant for Memory Devices, the robot complex "Beroe", and at university research centres. But no matter what field they have chosen, they have kept the creative spirit that they developed in these astronautical courses.

1.5.4. Space activities are to a great extent initiated and carried out by universities. Space projects are essential for innovation in setting research objectives and determining scientific content, for they affect a broad range of fields from metallurgy, technology of materials, jet propulsion, electromechanics, microelectronics, physics of vacuum and low temperatures, space physics, astronomy, geodesy, geophysics, oceanology, geology, hydrology, meteorology, medicine, biology and psychology to economics and law. Among other things, space activites have also helped universities renew their material and technical bases, improve their finances and expand their research and training staff. But the biggest advantage universities have gained from their active participation in space projects is their partnership into the new spirit of discovery, the creative dimensions of human daring in scientific research.

2. STATE-OF-THE ART SATELLITE COMMUNICATION TECHNOLOGY FOR UNIVERSITY TEACHING AND RESEARCH

2.1. Satellites for the Transmission of Educational Material Between Universities

A) Figure 1 shows the simplest version. Academic lectures, exercises, experiments, demonstrations, operations and other university training activities are properly selected (block 1); programmes are compiled by different ministries, organizations, agencies, scientific, cultural, educational and other groups (block 2); or eminent teachers, scientists, artists, governmental and other figures are selected (block 3) for specifically developed training programmes that are provided to the Centre for Training and Development of Educational Programmes (block 4). The respective programmes are transmitted directly or via the Training Centre to a Telecommunication Centre (block 5) and are broadcast to a space segment (block 6). After the necessary processing, change of frequency and other operations, the communication satellite (6') retransmits the programmes to earth-receiving centres.

Four types of such centres are worth noting:

1) Large receiving-transmitting earth stations (K1,K2,..), from which programmes are retransmitted by cable or by radio-relay line to local transmitters, providing regional coverage via radio and TV programmes (such systems are used in the USSR, Canada and USA at the first stage of educational satellite development.)

2) Specifically developed group or regional receiving stations with direct use of oral or TV-information or with retransmission to a limited region (G1,G2,G3,...). This is the system used in Canada's TELESAT with ANIK-A and ANIK-B satellites, supplied with two basic ground stations, eight receiving-transmitting stations, 80 group stations for receiving only, seven stations for radiotranslation, 14 for direct radio-receiving and two mobile TV stations for transmissions. In the USSR, there are "Ekran", "Statsionar-T" with 60 ground retransmission stations, and "Molnia"with 85 stations in the "Orbita" system. Indonesia's "Palapa" has 34 ground-receiving stations and retransmission from another 40 local TV-transmitters in the national TV system, and other.

3) Another version has receivers for direct receiving (d1,d2,d3,...) of audio or TV programmes. India's "CUTE" system has 2,400 TV-receivers, but it is special in the way receiving sites are grouped. The STS system has 0,6 to 1,6 diameter antennae, and demonstrations have been made in Peru, Australia, as well as in Ontario, Labrador, and other Canadian receiving stations.

4) Another version is a combined use of the previous three groupings. For small areas, the first and third groupings are combined, and for large ones, estimates show that the most economic is a combination of the second and third group (13,17,20). Direct TV-retransmissions of educational programmes have been in favour (13,17,29) but for university training, the group use of ground-based equipment will no doubt dominate, since it provides for the ultimate use of large, sophisticated equipment, including phototelegraphy, audio- and even video feedback, conference broadcasts, etc. It is worth noting that the system developed in Figure 1 provides for real-time and memorized transmissions of previously prepared programmes.

B) Figure 2 shows a more elaborate system, which ensures feedback between the user (university, college, etc.) and the Centre for Educational Programmes, i.e. the training link (university, professor, laboratory, observatory, etc.). In principle, for similar systems that are already in operation, feedback can be ensured either by an audio or by an audio-visual

channel. In the first instance, available telephone lines are used together with radio networks, whereas in the second instance, cable, optoelectronic or radio-relay retransmission of sound and image is used. Similar experimental systems have been partially developed for Canada's TELESAT. For greater distances, feedback can be achieved through selected channels in the satellite for educational uses (as can be seen in Figure 2: dotted line at right-hand side). Such a system was created during the DSMP experiment with ATS-1 and ATS-6 satellites, using eight transmission end stations and 119 receiving stations, 51 of which had audio-communication in both directions. In this version, satellites were also used for programme transmissions from universities in Kentucky to Lexington , Va, and their receiving from 15 TV-receivers. One out of three has a bilateral audio connection with the emitting university central station via ATS-3 satellite. The other two have feedback supported by ground communication lines, i.e. a mixed ground-based and satellite bilateral connection, exactly as is shown in Figure 2. We must add that such a bilateral link may be of the video type, in which case it is possible to obtain excellent conditions of conference performance (19,21).

In §15 of Ref. 13 it is assumed that even though the feedback circuit has been mapped out and experimented, it will most likely not be put to use because of the high cost of channels connecting users to the central transmitting station. In Ref. 21 the absence of a video-duplicated connection is compensated for by projecting before the students the portraits of the participants in the educational broadcast. Estimates have been made for the following undertakings:

1) transmission of questions and answers of trainees (to verify their understanding of the lectures) at precise intervals with a preliminary record and if possible, in telegraph mode;

2) development of short wave radio-lines at the universities which, even with lower transmission capacity, guarantees relatively cheap audio-feedback;

3) establishment of a system for express telegraphic or written correspondence in both directions, for testing students' knowledge and for answering their questions, examining their ideas, etc.

C) Figure 3 illustrates the most elaborate scheme, which allows for conference connections between all participants in the educational process. In this scheme, which works either by satellite or by ground communication lines, both direct and feedback links are established between all participants in the "teleconference". In such cases, the most expensive

equipment is necessary (especially when the link is not only audio, but audio-visual). Given current prices per channel (the minimum for Intelsat or Intersputnik), the possibilities for continuous educational broadcasts (or better yet, teleconferences) are rather limited. True, communication satellites are developing fast, and if governments help out, it may be possible to turn a profit, thereby allowing teleconference educational programmes to be used more widely.

For transmissions over long distances and for worldwide inter-university events (which will inevitably occur, especially if Unesco and universities correctly evaluate the potential for space-borne techniques for academic training), it is impossible to use only one communication satellite. Single or repeated retransmission between two or more satellites from ground telecommunication stations may be used. Another possibility was demonstrated at the laser technology exhibition held in 1984 in the Federal Republic of Germany. An intersatellite connection using a laser beam can transmit enormous amounts of information between satellites with very high quality. This advanced technique will definitely improve the possibilities for long-distance broadcasting of educational programmes.

At present, it is not feasible for financial reasons to set up separate satellite systems for individual universities. Co-operative undertakings are the key to effective satellite and university educational systems. Without underestimating the difficulties in establishing feedback and testing of students' progress, it is clear that only a combined application can make for a rational use of the advantages of space technology for educational purposes. In particular, satellite broadcasts can be very fruitful when they are in conjunction with written material (including tests), video-records (for repetition of lectures and exercises), and the like.

The advantages of regional (and even global) satellite broadcasts of educational programmes are:

- immediate and full coverage of a given region with possibilities for real-time performance and for dynamic educational variations;
- good transmission quality and costs that are affected only slightly be distance;
- the possibility of reaching remote or isolated areas, despite land or sea barriers;
- protection from natural calamities and to a great extent from natural conditions;
- irregardless of urbanization and distance, broadcasts can be given

priority.

In addition to these advantages, there are other, more specific ones linked to Figures 2 and 3. One major advantage is that it is possible to establish an active relationship between trainees and teachers. Even with a huge audience, intimacy of contact is not lost, since users at any one site are usually a small group. This means that trainees can be more active. This type of situation obviously requires a radically new pedagogical approach, but with the proper conditions, student participation can be greatly increased and new teaching methods could encourage questions and new ideas.

The special advantages of space-transmitted university lectures, exercises, experiments, demonstrations, etc. (especially in versions (B) and (C) examined here) are as follows:

- the most eminent professors can give a particular lecture or exercise or the most suitable laboratory can be used. This also means observatories, clinics, demonstration equipment, and the most qualified staff;
- new ideas, concepts, theories, experimental methods, testing, design and development can be exchanged. Both the student body and the training staff stand to gain;
- the educational process can be upgraded as the quality of teaching and organization are modelled after the best examples; the knowledge and concepts of the trainees are unified to a certain degree; and new guidelines are laid down to establish equivalent diplomas or scientific degrees;
- collective use can be made of unique or expensive laboratory equipment, botanical gardens, astronomy, geophysical and other observatories. Since no accelerators are available in Bulgaria, for example, future projects for educational programmes foresee access to Soviet accelerators in Serpuchov and Dubna through satellite communications. The exercises will be carried out in real time with bilateral audio-visual communication. In turn, Soviet history students will be able to study the origins of the Slavic alphabet at various places in Bulgaria, including the Rila monastery;
- stepped up university co-operation on the international level thanks to an exchange of experience and knowledge.

The advantages are particularly important for developing countries, which in this way can gain access to the teaching and research staffs and the high quality training processes of the developed countries. In turn, the universities of the developed countries can profit from the questions put by students and teachers in the developing countries, as well as from exercises set up to solve specific historical, ethnic, demographic, economic

or other problems posed by the developing countries. Unesco and the International Association of Universities should attempt to evaluate the conditions necessary for such exchanges and should direct their attention, financial capacities and energies to proposing solutions. They should alert other bodies, governments and experts to the possibilities held out by such exchanges.

2.2 University Participation in the Exploration of Outer Space

Part of the impact of satellite technology on teaching and research is university participation in the investigation and exploration of outer space. We mentioned earlier that universities are at the heart of most of the basic research space projects, such as the famous Dynamic Explorer project in the USA for the study of interactions between the magnetosphere and the ionosphere. The principal investigators were Texas University in Dallas and Michigan University, Ann Arbor. Significant participation in the scientific and technical programme for the flight of the first Bulgarian cosmonaut came from Sofia University, Kliment Ochridski, where four experiments were developed (two in metal melting and alloys under weightlessness and two on artifical crystal growth under low gravity). The Moscow University Lomonosov took a leading role in many Soviet projects in the field of space physics, astrodynamics (natural and artifical motion) and in research using satellite observations. We have already mentioned that participation in space activities radically innovates problems, methodology, raises the qualifications and consolidates the finances of most universities. Space research has increased the creativity and self-confidence of university staffs and the stature of universities in society. Though this deserves special attention it lies outside the scope of this report. But we would like to draw attention to the fact that the present relationship between the International Association of Universities and organizations such as the Committee for Peaceful Utilization of Outer Space (COPUOS) of the United Nations and its scientific, technical and legislative sub-committees, the UN Outer Space Division, the Committee for Space Research (COSPAR) at ICSU, the International Astronautical Federation, the International Astronautical Academy, the International Radio Scientific Union (URSI), the International Telecommunication Union (ITU) and other organizations is not sufficient. This is not meant as criticism but rather as a reminder that the more dynamic this relationship is, the more the effect will be on both the IAU and academic activities.

2.3. Satellite Applications: From the Dissemination of Scientific, Cultural and Educational Information to Improved International University Cooperation

2.3.1. The dissemination of knowledge at the present stage of the scientific and technological revolution is of particular importance.

1) It helps keep potential users informed about likely practical applications.

2) It increases the scientific level of society, so that it can more efficiently and more broadly absorb research results.

3) It broadens the intellectual basis for science and technology by involving large numbers of people, by increasing the prestige of science and scientific institutions and by helping to accelerate scientific and technical progress.

Universities occupy a prime place here. For example, about 20 per cent of the broadcasts of the Soviet space system "Orbita" are devoted to science and technology, and universities prepare about one third of these broadcasts. Universities play an important part in disseminating culture and educational broadcasts to all categories of trainees. For example, a system to actively involve students and trainees in teleconferencing was developed in college classrooms thanks to ground and satellite telecommunication complexes (21). H.I. Thorsheim undertook a large-scale experiment in Minnesota with the help of the American Association for the Advancement of Science Education and obtained encouraging results (32,33).

The most novel aspect of the experiment lay in the specialized character of the lectures as well as in the way students were induced to put questions to eminent lecturers. The questions were classified and those that came up most often were put to the lecturers, who responded in real-time performance. When a difficulty arose, the answer was given by mail. The system effectively stimulated the active participation of students. The technological realization was by telephone lines and what is known as a "Speakerphone", but it can be done through satellites as well. This system is interesting because till now the major efforts of the UN, Unesco, ITU and other organizations have centred on the technical problems posed by satellite use. With this experiment, we are in fact dealing with the kind of problems posed by the new educational systems based on satellite broadcasts for lectures, exercises and the like. Also decisive are the new ways in which the training process will be organized, including the impact of satellites on teaching methods, which is now in its early stages.

(See also 34 to 39.)

2.3.2. Specialized tele-educational programmes for extramural students are disseminated in the USSR through the "Orbita" and "Ekran-T" systems, as we pointed out earlier. Feedback between students and the respective universities is ensured by mail. Testing is done in normal examination sessions. Special broadcasts are devoted to consultations and answers to typical student problems are given by mail.

Also in the USSR, the Society for the Dissemination of Knowledge, called "Znanie", organizes television lecture series on economic, political, philosophic, social, technical and health subjects, among others, which are transmitted by satellite to the Far Northern and Eastern regions.

2.3.3. In 1979-1980 a series of television broadcasts on the achievements of Soviet cosmonautics and the peaceful exploration of outer space were broadcast by Molniya-1 satellite to Cuba, Mongolia and Vietnam. A substantial part of these programmes was prepared by universities and research institutes. As we saw earlier, space subjects are very attractive and can go a long way to involve the public in science and technology. This is even more important for developing countries. At present, the Intersputnik system is being used to broadcast popular science programmes, in which the universities have taken an active part.

2.3.4. Television, and in particular television by satellite ,has been widely used to disseminate knowledge among young people. Extra-curricular education plays a large role in the television programmes of Eastern European countries and the USSR. Of special interest has been a number of contests dealing with space, health, pedagogic and linguistic subjects, among others. A contest called "Young Intercosmos" was held in 1982-1983. The terms of participation were advertized on television, and for Eastern and Northern USSR regions, Cuba, Mongolia, and Vietnam, this information was broadcast by satellite. The young participants (up to 18 years of age) came up with interesting ideas and illuminated many space problems in an original manner.

2.3.5. Similarly, retransmission by satellite has been important in the dissemination of cultural information, and in particular of university lectures on art history and theory, which analysed the treasures of Leningrad's Hermitage Museum and the Russian Museum in Moscow. Another series was devoted to the Soviet ballet, which included research on the methods used to train dancers. The programmes were transmitted by "Molniya" and "Ekran-T" to the member countries of Intersputnik in America, Asia, and the Near East.

2.3.6. A satellite system for space data transmission is now being

experimented in the Intercosmos programme. Tests were run from 1981 to 1984 between the Central Laboratory for Space Research (CLKI) at the Bulgarian Academy of Science and the Institute for Space Research (IKI) at the USSR Academy of Science in Sofia and Moscow respectively. The data obtained from the satellite Intercosmos-Bulgaria-1300 were transmitted in real time by a telephone radio-relay channel between Moscow and Sofia. The data reached Moscow from the receiving centre in Evpatoria via powerful ground radio-lines, supplied with appropriate modems. Thus scientists at the Bulgarian and Soviet universities and research institutes could control in real time the measurements of this satellite for a very dynamic research programme on magnetospheric- ionospheric interactions.

Today the system is being developed further, using three different methods:

1) the Moskva ground-based station, which is a typical group receiver-transmitter for direct TV and permits educational and other broadcasts to be duplicated, as well as bilateral transmission of scientific, economic, commercial and other data;

2) the satellites and ground-based stations of the International Communication Satellite System "Intersputnik";

3) a specialized ground-based station for fast, two-directional transmission of scientific data with communication satellites.

Starting in 1985, experiments between Budapest (ground station Moskva) and IKI in Moscow were carried out. Now similar experiments are being carried out between the USSR and the GDR, the USSR and Czechoslovakia, and the USSR and Poland. Experiments with the new type of ground station will soon get under way between Stara Zagora (Bulgaria) and IKI (USSR). An International Situation Centre is now in operation at Stara Zagora; among other things, it collects satellite and rocket data. Its radiotelemetric station will transmit satellite data from the USSR and then back to IKI (Moscow). After testing, the system will be used not only for space data transmission but also for other scientific and technological information and results. This will furnish data to the scientific and production centre at Stara Zagora, which includes two high schools (radiotechniques and medicine). The nearby University of Plovdiv will also be supported by radio-line. A real-time performance is used for the transmission of scientific data (which allows for efficient control of experiments). Standard transfer of memorized data is also made. In the second case, the Intersputnik channels that are not completely loaded are used during the night, which makes retransmission much cheaper.

2.3.7. One of the first satellite lines was established between Sofia

and Moscow for the transmission of scientific information. This line connects the computer centres at the Soviet and Bulgarian Centres for Scientific and Technical Information (TSINTI). In this way, transmission of bibliographic, patent, and other information could be stepped up and updated. In the future, regional and global information systems will be able to solve most of the problems posed by the information explosion. Already, the informational satellite channel linking Sofia and Moscow, that has been in operation since 1983, has been of great assistance to Bulgarian universities.

2.3.8. The computer-orientation of education and, in particular, the mass application of computer techniques to all stages of the educational and research process in universities is the hallmark of the Second Educational Revolution, to adopt the term used by the Christian Science Monitor in February 1983. The inter-university computer connection provides access to the world's biggest computers, to large national, regional and world data centres and other training and research operations, on a scale that till recently was impossible. A new generation of big computers has now been developed in the USA to meet the needs of inter-university computer centres. In 1985, the US Congress approved the order for five such computers. The long-distance connection between these centres will be made by satellite. International access to the centres will also be by satellite.

The World Centre for Rockets and Satellites now operating in Greenbelt (USA), Moscow (USSR) and Tokyo (Japan) are connected by mail and by standard telecommunication channels (some of which pass through satellites). The possibility for their being connected directly by satellite is presently being explored. A similar situation pertains in the World Centres for Geophysical Data in Boulder (USA), Strasbourg (France), Moscow (USSR) and Tokyo (Japan). In particular, the World Data Centre A for geophysical data at the University of Colorado in Boulder is connected, including satellite lines, with many other universities in the United States and abroad.

2.3.9. Christo Botev campus near Sofia, an inter-university computer centre is now under construction. It will support secondary schools with over 20,000 students. An additional 5,000 students and specialists will do their post-graduate studies there. The centre covering over 6,000 square metres, will use advanced computer techniques, and there will be hundreds of terminals. Future engineers, economists, geologists, chemists, forestry experts and even athletes will be trained there. An automatic control system for the entire university will be set up at the centre, which will

significantly improve academic training as well as the system for technical supplies, the selection of professors, the organization of university activities and administration. Common scientific, technical and bibliographic facilities will also be provided. By 1990, the inter-university centre will become a National Training and Information Controlling Centre for the Bulgarian education system. It will be connected by ground-based communication lines with all institutions of higher learning in the country and with other computer systems. Most of the Centre's international relations will be conducted by satellite. Provisions for this have been made at the ground-based station for satellite communications at Plana Mountain, near Sofia.

1.2.10. When discussing the relationship between computer-orientation and the introduction of satellite technologies in education, it is important to remember that Bulgaria has relatively little experience. Thus far, we have primarily discussed hardware facilities, but many problems concerning software still have to be solved. That is why Bulgaria's youth group for engineering and economics, "Avangard", is producing, among other things, software products. Young teachers, students and even pupils are supplied with personal computers or terminals at home or in school laboratories and receive payment for their participation in the development of software programmes. Courses are organized for managers and specialists from industrial corporations, agro-industrial complexes and other and other potential users to advertize the software products developed primarily by students. Introductory lectures and practical explanations on the various software programmes are given on television. It is worth noting that space experts play a quite active role in "Avangard", and many of the space software products can, with minor variations, be applied to other fields of endeavour. Demonstrations of software programmes and their possible applications can be transmitted to other countries by satellite. These satellite lines guarantee fast and safe transmission of software products.

There are close ties between space specialists and the youth clubs called "Computer", which group over 120,000 youngsters. The clubs are designed to help youth assimilate new knowledge. It is a specific example of the transfer of space software to raise the level both of students and of the population at large.

2.3.11. Satellite communication systems permit symposia and workshops on a regional or worldwide basis without having to transport participants to one place. Just such a teleconference was held, for example, between Washington, Stockholm and Moscow by the Stockholm

Institute of Peace Research (SIPRI) on 5 July, 1985, as part of the international conference on "Space Weapons and International Security". Participants selected their spokesmen, and the USSR and the USA each designated one spokesman apiece. The spokesmen at the international conference and in Moscow and Washington had bilateral audio-visual communication, while the other participants at the conference could watch the discussion, as well as put their questions and make short statements on an audio channel. Of course, the broadcast was very expensive (two satellites were used, as were multiple ground telecommunication facilities) but the advantages were patent. No doubt the cost of the space component will be significantly reduced in the years to come, and it is to be hoped that teleconferences will become an advanced international practice in the near future.

We shall discuss the problem of the cost and organization of such broadcasts in a moment.

2.4. Improving the Organization and Operation of Institutions of Higher Learning

Communication satellites can foster effective, rapid management by transmitting information from the university to its branches, as was done in a Canadian experiment (12). In similar fashion, Irkutsk University in the USSR is connected with its remote heliophysical observatory. Cornell University in the USA manages the Arecibo Observatory in Porto Rico, thanks in part to a telex connection via a communication satellite.

2.5. In response to a query concerning plans for the use of communication satellites for university education, Intercosmos, ESA, Arabsat and individual scientists in India, Indonesia, Iraq, and Greece state that there are practically no new projects for the use of satellites for university education and research. Intercosmos and the European Space Agency showed interest at the 1985 meeting of the presidents of the National Coordinating Institutions that adhere to the programme and is planning to discuss the possibility of developing such projects in Moscow(17). As for other countries, there are no projects other than those already mentioned; though they are interesting, they are not fully coordinated, nor are they unified into one programme.

3 THE NEED TO ESTABLISH A NEW "SPACE" METHODOLOGY AND PEDAGOGICS FOR TEACHING

The enthusiasm displayed in the 1960s for the first satellite

applications to education gradually died down and in many cases it was felt that the prospects for using the new technology were exaggerated. As Russian expert Belotserkovskiy points out, educational television broadcasts were quick to develop in the USSR after 1964, but progress is now quite slow. He ascribes this state of affairs to the fact that there are still many unresolved social and pedagogic problems. The same situation pertains in most other countries. It may be that as far as university education is concerned, not all of the great possibilities were apparent in the early 1960s. Progress is now being made thanks to the computer-orientation of education, digital methods in research equipment and with the change in the attitude of society and universities as a result of the scientific and technological revolution. In any case, to achieve relevant and broad applications of satellite technology to education, there is still a great deal to do.

A serious revamping of training material should be done to incorporate more data on natural phenomena, more direct broadcasts on training, scientific experiments and demonstration of operations (including industrial and technological ones), and more programmes on machines, tools and equipment (including unique research installations), to mention only a few. In other words, there should be less abstract descriptions and diagrams, and more pictures of natural processes and phenomena, of real laboratory experiments and observations, and so on. To do this, all possibilities should be explored: in nearby and remote universities, in factories, farms and scientific institutions, in medical and veterinary clinics, observatories, and the like. More information is needed on what individual countries and regions can offer specifically in the way of production processes or scientific experiments, among others. There should be a stock of information about professors, scientists, doctors, musicians, artists and architects, and all other types of professionals who could be called upon to contribute to educational programmes by satellite.

Solutions must also be found for all sorts of organizational planning for technical and financial problems, and those generated by international co-operation. In this connection, ways must be found to overcome language barriers, either by simultaneous translation, previous distribution of written material, or the selection of a common language for a given region. New teaching methods will have to be developed that will take into account ways to question and examine trainees, and to establish personal contacts with professors that are adapted to the space age. Under the auspices of the UN, Unesco, Congo, ITU and other international organizations, efficient, inexpensive international standard educational satellites will have to be

developed to create common access and relatively inexpensive space segments. To this end, the various types of ground-based stations should be standardized for group reception of satellite educational programmes, with or without feedback (video or audio). Once this is accomplished, a series of stations of varying complexity and price could be developed to fit different purposes. Then ground stations could be produced in series, and this would result in significant drops in price, thus facilitating access to ground equipment for satellite educational systems. A new type of support training facilities will also have to be set up with the complex ground-based satellite training system. Lastly, the possibilities offered by satellite communication in the service of educational systems will have to be made known to as broad a public as possible.

Usually the latter needs are more clearly perceived. To redress the situation, a number of concrete steps can be taken:

- Popularization of the possibilities of satellite systems for education among government leaders and officials in developing countries.
- Establishment of expert groups to explore the needs of various regions and groups of developing countries and to make proposals to solve their particular problems.
- Organization of regional or global workshops (similar to the COPUOS Workshops on Remote Sensing) to train specialists in "space" education with the support of the UN and host countries.
- Creation of basic methods and means for educational satellite systems by international organizations fo developing and developed countries.
- Organization of an international campaign to enlist the support of space governments and international space agencies for subsidies to develop specialized educational satellites and corresponding ground facilities.
- Creation on a voluntary basis of qualification, training and other courses for young people from developing countries to help them master space technology and software methods in education.

3.2. Co-operation Between Satellite Communication Experts and Education Specialists

3.2.1. Till now communication satellites have been used to transmit educational programmes, and there have been no satellites specificially designed to fit educational needs. It can be argued that such a satellite, and particularly one in geostationary orbit, is not absolutely necessary, especially since it will not function during the night. But educational

broadcasts and transmission of research data do have specific requirements, as far as payload and possibilities are concerned. These needs should be taken into account in the design of the satellite.

3.2.2. Teachers and professors are poorly acquainted with the possibilities of communication satellites and other space facilities. Yet they need to know about such things if they are to: make optimal use of available space facilities; develop new methods, means and pedagogical techniques for satellite applications; help develop ideas and technology for specialized communication satellites in a more realistic manner and for the future construction of complex orbiting platforms with educational purpose segments.

3.2.3. There is clearly a need to lay the groundwork for an exchange of ideas and information between space communication experts and specialists in education. Joint teams and working groups could be set up specifically to develop new methods and means of education (including spaceborne facilities). Only in this way can optimal use be made of the positive aspects of educational satellites. Moreover, this is probably the best way to solve the problems encountered in using satellites for the training process.

3.2.4. Special sessions on space and education have been organized by the International Astronautical Federation (IAF) and the International Astronautical Academy (IAA) at their annual congresses. (In 1985, for example, there were discussions on "Space Development, Global Problems and Educational Motivation".) These congresses are an excellent medium for the exchange of information: a good number of specialists in space telecommunications and spacecraft design, among others, attend these meetings. An effort should be made to attract leaders in education to these meetings, for this could lead to high level, interdisciplinary research. Unesco could be very useful in promoting such exchanges.

3.2.5. The Bulgarian National Committee for the Investigation and Exploration of Outer Space believes that the situation is ripe to hold a bi-annual workshop in Bulgaria on space methods and techniques for education. This workshop could become a meeting place for specialists from around the world to deal with the technical as well as pedagogical problems posed by educational satellites. The workshop could be followed up by periodical courses to train specialists from developing countries in the field of space methods and means in educational practices. With financial support from Unesco, COPUOS, ITU and IAU, Bulgaria can provide the necessary facilities to organize training courses for young people from developing countries, in particular at the International Situation Centre in

Stara Zagora.

3.3 Training of Specialists for Educational Space Methods

3.3.1. Given the fast-changing space technologies and the Second Educational Revolution, there is a real need for even more highly specialized people. This is one of the universities' great duties to their own future as well as to the future of education in general. At the present stage of development, it is necessary to give special training to experts in satellite informatics, satellite educational systems and techniques, and methodology and pedagogics of satellite educational transmission. What would be particularly useful would be to enrol them as postgraduates at Technical Universities with extra courses on the theory of education, pedagogics, etc. and at pedagogical and psychological faculties at other universities (here with extra courses on satellite technology and systems, space telecommunications, and the like.)

3.3.2. In the coming years, the no doubt intensive use of space methods and techniques in education will make it reasonable to train students graduating in specialities outlined above. In agreement with 3.3.1. it will be necessary to separate these specialities from space-communications (or other telecommunications), psychology, and teacher training, and to provide training of specialists in complex technical, methodological, psychological, organizational and other problems related to space methods and techniques for education.

4. COMMUNICATION SATELLITE TECHNOLOGY IN TEACHING AND RESEARCH IN THE COMING DECADES

Before moving on to projects that will affect education and research in the near future, it is useful to summarize the previous points examined.

1) Satellite techniques (for lectures, exercises, demonstrations, new technologies, constructions, equipment, medical operations, geomorphological forms, natural, economic, political, cultural and other events) open up vast possibilities for education.

2) Some possibilities are being experimented, but on the university level are poorly used.

3) The use of space methods and techniques in conjunction with computer facilities (new methods of data processing, digital pattern automation of the scientific experiment, and other innovations) will bring about great changes in the content, forms and organization of universities.

4) No thorough-going international projects are as yet available,

especially as concerns software for educational satellites and their efficient use.

5) International co-operation on a bilateral, regional or global basis is crucial.

6) The role of Unesco, COPUOS, ITU, AIU and other organizations in developing this cooperation, and especially as regards the developing countries, is great.

4.1. Projects and Ideas for the Coming Decades

4.1.1. The following are plans being developged within the framework of the Intercosmos programme:

a) Investigation of VH radiofrequency propagation in tropical and equatorial conditions at a joint international test site in Vietnam. The results will further the optimal assimilation of new radiofrequency bands, which will expand possibilities for educational broadcasts. Much of the results will be applied to developing countries near the equator.

b) Theoretical and experimental studies on multi-purpose space communication platforms will continue.

c) Specialists from the USSR, Bulgaria, Cuba, Vietnam, Mongolia and other countries will work on the best ways to use satellite broadcasts in combination with conventional methods of education, rational pedagogical patterns for the complex development of the educational satellite broadcasts and ground-based methods at all levels of education, including university. The results obtained will be of special interest to developing countries.

d) Experimental and operational activities will be deployed to develop satellite systems for data transmission (see part 2.3.6).

e) The network of scientific and technical information transmission (see part 2.3) is now being expanded. The experimental stage, between Sofia and Moscow, is now in operation. This network will cover all the centres for scientific and technical information in Eastern European countries. Much more ambitious projects are to begin after 1990.

4.1.2. The "OLYMPUS" programme is planned by ESA, the European Space Agency. A multi-purpose satellite was scheduled to be launched in 1987 and to include educational programmes. The first satellite of this type will cover Western and Central Europe, but if a second satellite is launched (this is still uncertain), pilot satellite broadcasting could cover Africa and South America as well.

4.1.3. Regardless of the fact that Arabsat is mainly oriented towards commercial telecommunications, it is considering the possibility of

including educational programmes for primary and secondary school in future satellites. At present, there are no known projects for direct applications of satellites to education or to study interactions at the academic level. According to our information on Irak, Morocco, Algeria and Egypt, it is likely that some governmental assistance will be forthcoming, especially if there is international support for projects with a view to advertizing the role of satellite broadcasts for university activities.

4.1.4. As we saw earlier, there is a dearth of global projects. The fact that there are only partial regional or bilateral projects points to great and as yet unsolved psychological, social, economic, financial and information difficulties.

5 TECHNICAL AND FINANCIAL PROBLEMS AND THE ROLE OF INTERNATIONAL CO-OPERATION

The operating possibilities of satellites for direct broadcasting for educational purposes, problems of coverage, satellite instrumentation, power, orbit, frequency, coordination, cost, etc. have been explored (see 2,3,6 to 13,16,17,19 and 39 to 46).

5.1. Technical Problems of the Developing Countries

With regard to developing countries, we should note the following:

a) Developing countries can participate in national, regional and global systems for "space education". India, Indonesia, Brazil as well as one or two other Third World countries have the capacity to develop their own national systems. But the advantages of satellite education systems are especially striking on the regional level, particularly as regards university education and research. Regional possibilities are enormous, especially in Latin America. These countries could share their own part of a geostationary satellite, for they have a common language, similar educational systems, a common religion, and similar economic, scientific and technical, and political problems. All this makes for a solid basis to create common satellite educational programmes on a regional basis. If such a system were established, it would significantly improve communications between these countries (close time belts enable them to load the system with commercial information, in addition to educational broadcasts) and could contribute to closer ties and to a gradual harmonization of material and intellectual development. Similar possibilities also exist for Southeast Asia, North Africa and other regions.

b) Developing countries can acquire an educational space system on a

regional or national basis in various ways:

1) by buying or borrowing a satellite with complex ground equipment and by recommending the import of software for education;

2) by buying or borrowing a space segment and developing national or common ground-based facilities, as well as common programmes;

3) by buying or borrowing a space segment and improving available ground equipment with national software that is protected by a national or regional organization;

4) alongside the construction (independently or with assistance from abroad) of a national space segment, the establishment of a complex organization, software, pedagogics and other elements of an educational space system.

The last arrangement is obviously the most rational and efficient, and it ensures that all the national components are protected. But the lack of specialists, laboratories, plants and insufficient financial aid makes this solution quite difficult for Third World countries to achieve. Yet if all efforts are joined and if there is a will to provide aid by the international organizations, or on the bilateral level, then this solution is the most efficient and has the most spin-off effects, not only for education but also for the overall scientific, technical and economic development of a given country. Because such sophisticated technology will be assimilated, space research can accelerate development in many other scientific and technical fields and can modernize other vital sectors in Third World countries. We are not entirely in agreement with a number of statements made by developing countries during a working group meeting at the UNISPACE-82 Conference. They asked for "more accessible, lower range educational broadcasts and telecommunications for Third World countries, due to the very complex and sophisticated and therefore inaccessible character of the 11/12 GHz range and of higher ranges as well." In our opinion, on the contrary, a necessary component of the "national strategy" of small and developing countries should be a mobilization of effort for the most advanced domains. There should be attempts to resolve ongoing problems; this cannot be achieved by continuously stepping back into the rearguard of progress (47).

c) We should like to emphasize that space technology transfer and spin-offs (including software) have greater and more accelerating effects on Third World countries using "space" education. Even for professors and students from developed countries, the use of educational satellites is an

innovative and stimulating factor for all participants and makes them familiar with the most advanced achievements of contemporary technology. But for students and teachers in the Third world, "space" education means that they can reach the top of the present educational process on an equal basis with their colleagues from the developed countries. Moreover, with satellite access to information centres, data banks, and with indirect contacts with modern research facilities, the basis for real transfer and spin-offs to other spheres of activity can be established.

5.4. Optimization and Planning

The optimization and planning of "space" education as well as its realization should be always as concrete as possible. They should address the problem of complex, combined methods of education, where an appropriate allotment of ground-based methods and techniques is very important, especially when put in the national and regional context. (See 2,3,8,10 through 13,17,19,37,44,45 for recommendations.) Unesco and IAU should pay particular attention to this problem in the future.

5.5. The Role of the United Nations System: COPUOS, UNDP, Unesco and Other

The outstanding importance of "space" education was recognized early on by the UN at the first UN conference on the Peaceful Investigation and Exploration of Outer Space held in Vienna in 1968. It was clear that the space age would stimulate interest in and provide great motivation for education because of the attractiveness of the space sciences. During the preparation of UNISPACE-82, there was a realization that educational broadcasting by satellites was in the domain of the possible. With the implementation of resolutions adopted at UNISPACE-82, the UN and COPUOS have made significant contributions to the development of space educational activities. Yet much remains to be done. If we compare the number of workshops on remote sensing with those on "space" education in the United Nations Space Applications Programme, it is clear that application-oriented subjects on teledetection still dominate. Therefore one of the recommendations we should like to make is that the number of workshops on "space" education in the UN Outer Space Division should be sharply increased in order to establish a serious programme for the development of satellite educational networks. An expert group on "space" education should take a new orientation and concentrate on the search for methods and means to develop space educational systems and for securing international support for their construction and functioning, rather than

discussing technical matters. In this respect, Unesco could apply for funds to the UNDP for the construction of an experimental educational system for Africa or Latin America, for example. Nor should the working group be content with programmes only for primary and secondary school education, which are perhaps easier to develop. The system should include university education and postgraduate courses, and the dissemination of knowledge in general.

5.6. The role of International Governmental Organizations (ITU, CCIR, CCITT, WMO, WHO, among others)

The ITU and its sub-divisions, the CCIR, CCITT, and various task groups, have an important role to play, though it must not be forgotten that ITU is not an education-oriented organization and that very often its activities differ from those of Unesco and IAU. It is worth noting that there is no organization specifically devoted to the interests of educational satellite needs for optimal frequencies, power supply, location of the space segment, protective ratios of the signal level and other technical specifications. Yet educational satellites will be one of the most important and useful international group applications of space communication potential. Therefore, an organized representation of universities and other institutions of higher learning should be adhered to the respective WARS. This is an important duty of Unesco, and COPUOS, but also of the IAU. Other international governmental organizations, such as WMO, WHO, etc., should also more resolutely defend educational interests in their own domains vis-à-vis the ITU. Very often at WARS and in other ITU activities, national interests predominate at the expense of the relatively passive international organizations.

5.7. The Role of the International Council of Scientific Unions (ICSU) and the ICSU Bodies (COSPAR, IAU, URSI, CODATA, SCOSTEP, among others)

The international scientific community, the greater part of which is found in universities, is primarily concerned with the development of satellite methods for teaching and research. The international scientific unions that belong to ICSU have great regard for the possibilities of satellite educational systems. A number of them, including the International Astronautical Union (IAU), the International Radio Science Union (URSI), UIPAP, IUGG and IAGA, have space research themes and objectives. Many of the studies use radiofrequencies (for example, in radio-astronomy, for telemetry and teleguidance of scientific satellites,

ionospheric stations, etc.), and that is why a Radiofrequency Commission was set up. It functions within the framework of the ICSU Committee for Space Research (COSPAR). The ICSU Committee on Data Exchange (CODATA) is also very interested in the application of satellite channels for data exchange.

Indeed, all the international scientific stand to benefit from satellite educational systems and could assist in the establishment of a methodology and proper organization of "space" education. That is why ICSU and its members like COSPAR should join the International Association of Universities, Unesco and ITU in devising the best solutions to the problems raised here.

5.8. The Role of Other International Non-Governmental Organizations, Including IAU

The Committee of Non-governmental Organizations (CONGO) should also concentrate its activity on satellite educational systems. Here the role of the International Association of Universities is vital. It could tackle at least three major tasks: it could clarify and popularize the possibilities of satellite broadcasts for the development of innovations in university teaching and research; help develop methodology, methods, and means for "space" education and, in particular, in a reasonable and relevant combination with ground-based components for research and education; become a centre for meetings and joint activities of professors and specialists from different types of universities, including technical ones, to discuss the problems posed by educational satellites and their impact on university activities and organization.

Three other organizations - the International Astronautical Federation (IAF), the International Astronautical Academy (IAA) and the International Institute of Space Law - should play a leading role in the analysis of problems related to the space age and education. Starting in the 1960s, the IAF included these problems in its annual sessions, and the IAA also promotes similar activities. It might be useful if the IAU and Unesco were to support these annual IAF and IAA sessions and ensure that their activities are applied on a much wider scale.

5.9. Bilateral Collaboration

Examples of successful collaboration, such as the experiments by the USA and India, and that of USSR and Cuba, to mention only two, should receive energetic support.

6 CONCLUSIONS

We shall limit our comments here to facts and figures, or in other words, to a brief examination of the cost involved in satellite educational programmes. A simple version of a communication satellite costs about US$35 million, while satellites of the Insat and Arabsat type cost about $50 million. As for direct broadcasting satellites with three to six high power channels for individual reception at 12 GHz might cost $60-90 million and those with 16 high power direct channels have been estimated to cost $140. However, the Viking satellite developed in Sweden costs $1.5 million and the Intercosmos-Bulgaria-1300 made by the USSR and Bulgaria was significantly less. Much cheaper boosters are developed in the USSR, Japan and other countries. All this information, together with data provided by COSPAR and IAF, leads us to believe that by the end of this decade, satellites for direct broadcasting with 24 channels and the possibility of multistationary access in the transfer of audio-feedback will cost from about $90 million to $120 million.

The ground stations for direct TV (individual receiving) are sold by Japan for $380. For high quality group receiving, the price may be well below $1,000.

Developing a specific educational satellite system would be easier to solve if there were even a symbolic cut in military expenditures. A cut of just 0.5 per cent in the US 1985/86 budget would be sufficient to build a world educational system. A mere 6 per cent of the $26 billion scheduled for research on "Star Wars"/SDI over the next few years could finance a super-modern world educational system, with subsystems for regional coverage, collection and transmission of scientific data, communications between universities and educational centres and other educational purposes (including both space and ground segments).

IAU or Unesco could propose that the developed countries create on a co-operative basis their own experimental educational satellite supplied with display ground facilities. A system for "space" education could thus be popularized, and foundations laid for its broader use. As we have seen, the development of such a system is feasible and possible.

Unesco, the UN, and IAU have already taken the initiative in this domain. They could pursue their efforts by establishing a permanent working group at Unesco and/or by organizing workshops and symposia on this vital issue.

BIBLIOGRAPHY

1. K. Serafimov, Space-orientation of Science, (Bulg), Scientific Life, No 1, 1978, p.19.
2. Preparation and Training of Space Equipment Users, Reference book, UNISPACE-82 (Russ.), UN, Doc. No A/Conf. 101/BP/9, 1982.
3. Report, Second UN conference on Investigation and Exploration of Outer Space for Peaceful Purposes (Russ.), Doc. A/Conf. 101/3, 1982
4. Alternative Space Futures and the Human Condition, Round Table Discussion, UNISPACE-82, Edited by K.S. Karnik, Pergamon Press, 1982
5. K. Serafimov, Space-orientation of Higher Education (Bulg.), Problems of Higher Education, Sofia, 1977
6. The World in Space, United Nations, Ed. Ralph Chapman, Prentice Hall, Inc., New Jersey, 1982
7. K.S. Karnik, N. Sampath, UN-Unesco Panel Meeting on SITE Experiences, Space Appl. Center, Ahmedabad, 1977
8. Feasibility Study of Regional System of Tele-education for the Countries of South America, v.1, v.2, Unesco, France, 1975
9. R. Chander, K. Karnik, Planning for Satellite Broadcasting, The Indian Instrumentational Television Experiment, Unesco, France, 1976
10. Feasibility of a Satellite Sound-broadcasting System for a National Service with Portable Receivers, European Broadcasting Union-CCIR Study Group SPM (WARS-79) Geneva, 1978
11. Department of Communication, A Satellite Delivered Direct-to-Home Television Pilot Project, Ottawa, May, 1980
12. United Nations Scientific and Technological Subcommittee for Peaceful Use of Outer space, "The Feasibility of Using Direct Broadcasting Satellites for Educational Purposes and of Internationally or Regionally owned Space Segments." Expert Group for Direct Broadcasting of Satellites for Vocational Purposes. Vienna, 1984
13. W.T. Kerr, B.C. Bleviv, Telecommunications Services for Rural and Remote Areas, Telematics and Informatics, v.1, No 1, 1984, 37
14. K. Serafimov, Space and Education (Bulg.), Teachers Business, No 36, 3 Oct., 1972, p.2.
15. K. Serafimov, Space and Man (Bulg.), Teachers Business, No 12, 7 April, 1981, p.2.
16. O.M. Belotserchovskiy, Space and Education (Russ.) Znanie Ed., M., 1972
17. J. Chaplin, "The Feasibility of Using Direct Broadcasting Satellites for Education Purposes," ESA, Doc. CCB/36656/J.C./CMM=(5), 1984
18. K. Serafimov, "The Space Age As a Generator of the Second Educational Revolution," 36th IAF Congress, Stockholm, 1985, Rep. IAF-85-442
19. "Technical and Economic Basis and Planning of Educational Satellite Systems," Ref. Doc. (Russ.) UNISPACE-82, UN Doc. A/Conf. 101/BP/6, 1982
20. K. Serafimov, "On the Increase of the Efficiency and Productivity of the Scientific Process" (Bulg.), Edition of the Union of Scientific Workers in Bulgaria, Sofia, 1983
21. H.I. Thorsheim, "Teleconferencing from the College Classroom," 36th IAF Congress., Stockholm, 1985, Rep. IAF-85-451
22. "Science for Technology for Development," Rep. of Experts Group, Commonwealth Science Council, London, 1984
23. K. Serafimov, G. Ivanov, "The Space Age as a Stimulant of Cultural Development," 31st IAF Congress, Tokyo, 1980, Rep. No 80-D-321
24. K. Serafimov, G. Ivanov, "The Influence of the Space Age on the Global Humanistic Psychology, 32nd IAF Congress, Rome, 1981, Rep. IAF-81-275
25. K. Serafimov, G. Ivanov, "The Space Age Stimulant of Cultural Development (Bulg.), Narodno kultura, No. 46, 14 Oct., 1980, p.1

26. De L'ontologie de la conquête de l'espace, L'Académie du Royaume du Maroc, Casablanca, 1984
27. L.W. Dawid, "Space as Motivational Propulsion," 35th IAF Congress, Lausanne, 1984, Rep. IAF-84-407
28. G. Pignolet, "Building Space Station Models Brings Educational Benefits," 35th IAF Congress, Lausanne, 1984, Rep. IAF-84-416
29. K. Serafimov, "Satellite Radioelectronic Systems for Higher Education," (Bulg.), Radio and Television, No. 1, 1986
30. K. Serafimov, "Space Research in Bulgaria", Edition of the Bulgarian Academy of Sciences, Sofia, 1979
31. K. Serafimov, "Bulgarian Space Activities," Advance in Space Research, v.3, No. 10/12, 1984, p.1.
32. H. Thorsheim, K. Dybdal, "Impact of Space Development on Educational Motivation", Earth-Oriented Applications of Space Technology, 2, 1982, 153
33. H. Thorsheim, K. Dybdal, "Evaluating the Impact of Space Development on Educational Motivation," Earth-Oriented Applications of Space Technology, 3, 1983, 273
34. R.C. Atkinson, "Education for an Age of Science," Science, 223 (4643), March 1984, p.1355
35. S. Beer, "Platform for Change," New York, Ed. Wiley, 1975
36. National Institute of Education, "Involvement in Learning: Realizing the Potential of Higher Education," October 1984
37. K. Samuelson, Informaticon, "A Multi-way Videocommunication System for Interregional Resource Development, and International Education in Informatics and System Science," in: Unesco Symposium on Regional Cooperation, September 1983, Stockholm, Ed. North-Holland, Amsterdam, 1984
38. K. Serafimov, "New Ways to Use Satellites in Educational Systems," (Bulg.), Problems of Higher Education, 1986
39. K. Serafimov, G. Genchev, "Space Radioelectron Systems," (Bulg.) Military Ed., Sofia, 1972
40. B. Balabanov, "Satellite Communications," (Bulg.) Ed. Technika, Sofia, 1982
41. Technical Rep. for WARS-84, Interim Working Party 4/1, Doc. Plen. 10-E, CCIR, 1984
42. Radio Regulations, Ed. ITU, 1982
43. Recommendations and Reports of the CCIR, 1982, v.IV, Part I, (Fixed Satellite Service), 1982
44. Recommendations and Reports of CCIR, 1982, v.X, and XI, Part II, Broadcasting Satellite Service (Sound and Television), 1982
45. Contribution of the International Radio Consultative Committee to UNISPACE-82 (Doc. A/Conf./101/BP/IGO/9), 1982
46. Role of the CCIR in Space Telecommunication Technology (Doc. A/Conf./101/BP/IGO/14), 1982
47. K. Serafimov, "Selective Space Strategies for Small Countries," Space Policy, v.1. No. 4, 1985

Section IV

Jose Luiz BRAGA

Telecommunications for University Teaching and Research (An approach to some educational problems)

TELECOMMUNICATIONS FOR UNIVERSITY TEACHING AND RESEARCH

(AN APPROACH TO SOME EDUCATIONAL PROBLEMS)

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The text that follows was elaborated as a reflection after reading three documents prepared in the behalf of the Steering Committee for the UNESCO/IAU Joint Research Programme in Higher Education.

These three documents deal with subjects on the field of communication satellite technologies for educational uses. They discuss mainly the perceived or eventually tested possibilities of satellites for amplifying access to information and for integrating higher educational institutions across the world. Although some specifically technical problems on telecommunications are treated, the documents are devoted chiefly to the possibilities of distribution, and to the promises contained in the use of these technologies; they relate experiences at several regions of the planet; they consider cost problems; and they refer to types of communication which could be employed for educational purposes (still or full motion visual transmission, sound transmission, graphics, facsimile; one-way or two way channels; group communication, etc.).

Some educational questions are approached by the three documents without the objective of detailed analysis. Although the views are generally optimistic, several problems are pointed out.

In my comment I try to underline the questions that seem to be the most intricate ones. They appear in three levels not deeply examined by the basic documents studied:

- the relationship between the national and the international tasks;

- questions refering to educational use of modern means at the learning end of systems;

- questions referring to the production of educational materials (software).

I think these questions could complement those treated by the three documents commented.

- - -

My points of view are of course determined by a teaching experience in the field of Social Communication and of Education - in which cultural and social considerations have more weight than scientific/technological ones.

I have participate of a Brazilian experiment on the production of educational software whose final objective was the demonstration of feasibility of communication satellite uses for education. This was Project SACI - which I coordinated in one of its phases (ground experiment at Rio Grande do Norte). That experience convinced me that the crucial element (in the sense that it is the one which poses the most serious problems), is the educational software, its planning, production, and use.

I must also recognize my Brazilian and Latin-American prejudices. Even when I make general considerations about international relations on education, certainly my views are mainly determined by professional and life experience developed within this political, historical, cultural and geographical frame.

1. INTRODUCTION

[1.1]

The use of modern technologies (television, radio, computers, satellites...) for educational purposes remains a provocative novelty in spite of the fact that several experiments on the field have been done since the early sixties. For the overwhelming majority of people around the world, education is a word associated to a conceptual space defined by expressions like teacher, classroom, face-to-face personal relationship, books and copy-books.

Considering the important impact brought by electronics on the most different human activities - at economical, business,cultural, military levels - the desire of obtaining similar impact on education seems to be justified.

This is reinforced by the perspective that the educational purposes present a positive signification, of pacific, stimulating objectives for humankind (in opposition, for instance, with military uses).

The current phase, still largely dominated by an experimental non-operational situation, seems to emphasize the research on hardware possibilities for educational transmissions. As a matter of fact, the first experiments made had precisely that objective: to ascertain (or demonstrate) that electronic means are useful for educational purposes. At the same time, the current perspectives try to underline those possible uses as desirable ones. That would be motivated (among other reasons) for considerations of quantity (large dissemination, distant transmission); of costs (made viable and even favorable, in spite of heavy investment required, precisely because of the

large number of people potentially reached); of new interest and motivation (as a function of image transmission, of stimulus variety and richness); and of improved educational effectiveness (through near contact with phenomena and studied facts, because of fast access to data, etc.).

Today, perhaps, it is no more required to demonstrate that it is possible to use modern means for education: it seems generally accepted that they are desirable. But one cannot affirm that this desire for modern means activates the research and the establishment of operational systems and ways of working them.

Three documents elaborated by demand of International Association of Universities (IAU)/UNESCO Committee (*) deal with that situation. They propose (diversely, following the author) the possibilities and hopes of using electronic hardware in educational communications.

a) MEYERSON deals mainly with one of the forms for the dissemination of relevant information for learning: the teleconference ("as an adjunct to and sometimes a substitute for other kinds of human communication"). Teleconference is defined as "group communication through any electronic means". Based on experiences undertaken in US or other countries, national or international ones; and on the theoretical capabilities of electronic means, Meyerson considers the possibilities of group communication by audio and visual retransmission, by facsimile and other written devices, by computers networks, etc. He describes the state-of-art of technology as respect to these alternatives, considering their quality of transmission, relative costs, specific advantages and principal limits or lacks (from the perspective of technical resources and from the view of their purposes).

b) NOGUCHI and NEMOTO concentrate their paper in the "infrastructural requirements of research and education". They consider that the core of the infrastructure should be an information network which would have a satellite system

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(*) MEYERSON, Martin - The contribution of international telelearning to University teaching and research - an outline guide for users.

NOGUCHI, Shoichi and NEMOTO, Yoshiki - The impact of the satellite communication networks on research and education.

SERAFIMOV, Kiril - Impact of satellite technology on university training and research and the worldwide potential.

as the main element. Through reference of experiments realized in several countries (or between countries) they advance expectatives for a growing use in the future; and they propose the need for a worldwide information network system.

c) SERAFIMOV approaches the following points:

- the expansion of the educational tasks brought up by the space-oriented subjects;
- the state-of-art and current plans in the use of satellite for higher education;
- relationship between experts in telecommunications and other specialists engaged in training & research;
- predictable uses during next decades;
- technical and economic questions.

That sequence of items follow nearly the discussion points considered as relevant by IAU. Although Professor Kiril Serafimov treat those questions mainly from a technological and organizational point of view, he refers also to specifical educational questions, underlying the importance of their study. The technical and logistical possibilities and problems of satellite are emphasized, but Serafimov takes also serously in account the need for educational problem analysis. From the three documents presented (besides undeniable practical usefulness of Meyerson's text), Serafimov's is the one which studies more rigorously and seriously the principal questions involved in educational telecommunications.

[1.2]

The studies about educational uses of hardware are of course important. For the researchers and institutions that will assume tasks oriented for the development of these uses, they represent necessary information. Above all, they indicate the needed line along with which some efforts should be made in order to get over limits (of equipments and costs).

However, within the technological field, when limits exist, they can be hopefully surmounted by new development in the near future. The tendency seems to be directed to cost reduction, amplifiation of range, and simplifica-

tion of use conditions. The benefits of modern communication means seem to be more and more accessible, more easily, to a greater number of customers.

Other kinds of problems must be dealt with that cannot be surmounted only by new discoveries, and that are not dependent only upon technological decisions. Professor Serafimov points that although he deals mainly with information on hardware facilities "the general open problems refer to software provisions". Some documents are refered by Serafimov which treat that kind of questions - it would be useful if they could be largely disseminated among researchers in the field of educational telecommunications.

Within the non-technological questions I identify three areas that seem to be of utmost importance: the effective educational use to be made of resources technically available; the production of educational messages (software materials) which should be distributed by telecommunication systems; and the balance between national and international dimensions of educational telecommunications.

The studied documents do not analyse deeply these points. Since I think that those are questions which should interest every program in the field, my text is organized around problems within these areas. It is developed in three sections:

- between national and international instances;
- educational uses of electronic means;
- production of educational materials (software).

It is on the basis of the perspectives and problems proposed by these three points that I make my reading of the three IAU-documents. I do specific comments on the documents each time some point has been treated by one of the authors.

[1.3]

In order to conclude this introduction, something can be considered about the preferences of academic specialists about mass communications and educational technology. It is still frequent that some of them assume "aprioristic" positions, positive or negative, regarding to technology - mainly about the "great means" as is the case of satellite.

On one hand, there is an attitude of rejection, which sees in the

electronic "invasion" of education possibilities of massification and the risk of centralized decisions which would result in authoritarian controls of learning. Through this, there would be reductions of individual liberty or increased hegemony of one social group over other ones.

At the opposite side, there may be an emphatic positive view, which sees in modern technology an automatic redemption of servitudes, a sure way for peace and more solidarity between countries, a democratic access to the benefits of modern civilization, through first-rate education for all.

For someone who works in the field, it seems to be essential to surpass those simple extreme alternatives. The preference for emphasizing only the advantages of the technology may have been required to overcome initial barriers (or even, for some researchers, as a way of feeling that their experimental activities had some meaning). But today, it seems to be wiser, besides of studying objectively the possibilities, to examine the problems, the difficulties, and the limits within which the tasks should be contained.

Refusing the "apocalyptical" positions, it is required to avoid also an exagerated optimism: nothing permits to think that the simple use of modern means to education will radically transform society or man.

Options will be made (eventually for reasons distant of the educational objectives). Within the specific field of education, better or worse decisions can be made. In order to have some guarantee that we are making reasonable choices, it is best to analyse problems (perhaps even a bit sceptically) than to adopt too much positive positions, which risk floating between planning and the simple "selling" of an idea (with evident damages to sound planning and programming).

In the following text I propose mainly problems and questions. In no way I would intend to present arguments against the interest in cooperative programs on education via modern technologies - but I think that they only can achieve if they are able to take in account and to find adequate answers for those kind of problems.

2. BETWEEN NATIONAL AND INTERNATIONAL INSTANCES

[2.1]

Whichever would be the personal positions of researchers engaged in research & development of electronical technology for education, the options between national and international levels of activities will not be made exclusively in a basis of theoretical preferences which may suggest a technical or educational "optimum".

Future decisions of countries, groups of countries, governments, higher education institutions, international organizations, will be dictated by global objectives of those who have the initiative of planning and acting. Those decisions will also be dependent on national options refering to local and regional political situations; to geographical and territorial conditions; to socio-economical considerations and to the level of country development.

A mainly technological view, when we deal with communication satellites, tends to largely emphasize internationalist preferences. This orientation is suggested by the wide coverage made possible by satellites (*); by the large number of people that could be reached instantaneously via communications technology, what makes possible worldwide reception of any educational transmission (and then, desirable worldwide emissions); and by the large costs of implementing diffusion systems by satellite (to be shared among many participants). Satellite use for educational purposes in a national level would mean, for the greater number of small countries, the impossibility of supporting the required

(*) Noguchi and Nemoto remind us that a system composed by only three stationary satellites would cover almost the totality of the planet.

investments and a waste of resources. And it would bring up additional problems - as overlap of covering areas, questions over frequency distribution, and eventually overcrowding of the stationary orbit. On the other hand, as Serafimov points out (p. 9), by the end of the century "even for the dimension of relatively small countries the use of communication satellites will be more efficient" than ground transmission.

Following another line of reasoning, the internationalist hypothesis is also to be preferred. The increasing interdependence of nations, in a planetary level, composes complex networks of interaction, not always amicable, between countries and regions. All effort for international cooperation appears to be an important step to strengthen understanding and to promote peace. Among those efforts, education, as a universally positive value, seems to carry possibilities of approximating nations.

Within this line of ideas, the fight against misery and underdevelopment suggests that poorly supplied countries should look beyond frontiers for the support in order to get over their concrete problems. Among the kinds of possible support, the educational contributions seem to be relevant in the extent of the multiplying effects that can be expected for the increases in cultural and professional qualification of inhabitants. That need for external support would represent then a stimulus to international action: via accords between developing and industrialized countries; via programs stimulated or supported by international organizations; and via accords between developing countries of the same region for dealing, through joint programs, with similar educational problems.

[2.2]

However, some concrete limits are frequently put before internationalist preferences. Some decisions may be made from a nationalist point of view. The international support offers the means to surmount poverty, but it may also bring some risk of greater dependence. In that line, the participation of international organizations would lower the risks.

Anyway, questions as, for example, what should be taught (mainly at higher education) need to pass by national decisions - in order to avoid preferences made in the basis of external perspectives - possibly theoretically defendable, but which would turn aside from legitimate interests of a country.

Cultural questions make possible to focus some problems of educational action at international level. The language barrier limits somehow the possibilities of interchange. Three orders of consideration may be made about that problem.

a) The English language is a means of international communication. Much educational materials, scientific and technical data is made available through that language. The satellite use in international higher educational systems will emphasize that. English language, mainly in higher education & research, will make feasible satellite systems. Already the computer programs are characterized by extended use of English terminology.

But it remains that the bulk of educational communication will need to be made in the language of each country and following its habitudes of communication. Language choices represent then a quantitative limitation for what can come to be subject to international education via satellite.

b) On the other hand, as for language barriers, there exist palliatives, based on traditional solutions for exchanging cultural products between countries: text translation, simultaneous translation, use of captions and legends, etc. By the way, this is one of the points considered by Serafimov (p.28). It is true that, for large distribution of audiovisual materials, this represents aditional efforts and increased cost - but shall be faced as an essential element for general access to educational software.

c) Precisely as a consequence of the limits above (among other sorts of consideration) we could foresee a preference for using educational satellites within homogeneous linguistic areas. It would be the case, for instance, of Hispano-America. The same can be said of great number of countries around the world that have English as their historic language or that adopted it as official language.

Even if language community is a very positive factor for cooperative programs, we should not forget that not all countries using the same language present the same cultural, political, historical background. Even when they originate from the same historical propagation (as the case of Hispano-America), they may present profound political and socio-economical differences - and perhaps mutual distrust - which would limit joint programs.

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Besides language problems, cultural and social differentiated characteristics should be taken in account. Contemporaneous civilization unifies many aspects of life, but the persistence of cultural identity should be preserved - which may justify some grade of nationalism. One of the questions to be proposed under this title is the one of deciding which kinds of knowledge would be more generally accepted for international exchanges in higher education; and which ones would be less appropriate. The large partitions are more or less obvious: exact and natural sciences and modern technology would be more universal, and humanities and cultural disciplines would be more dependent on national views. But for each great field of knowledge it remains important to examine differentiated areas and methodologies following learning needs, corresponding to geographical, social, economical and cultural variation.

Professor Serafimov suggests that "a thorough training is needed together with certain unification of methodologies, terminology, content of the educational emissions and other problems in order to realize completely an international education programme" (p.26). That unification is possible and desirable on many subjects but perhaps for some other matters it would be required research and training about variety instead.

Another question, also neatly cultural, refer to a certain caution against cultural predomination of some countries. Even if international organizations can help maintaining delicate balance, industrialized countries are the ones which have the best conditions for supplying educational software and trained specialists for international programs; and developing countries are the ones which have more needs for receiving these programs.

Industrialized countries present high proportion of people engaged in tertiary work (where we find the educational tasks). Eventually they present also a certain level of highly qualified unemployment. Developing countries, on the contrary, may have shortage of qualified professional for tertiary work, mainly for modern educational tasks; and unemployment of underqualified people. The temptation of attacking both problems as complementary ones by international education programs may be too strong.

In mass communications, the current international flow of products - musical, cinematographical, televisual ones - has well defined courses. It may hapen that local cultural-artistic production be compressed since it cannot compete with low-price high-quality external products. An international educational production would possibly present the same tendencies shown by cultural/commercial mass communications.

On the other hand, enriching possibilities of exchange of educational products may and must be taken in account. Serafimov illustrates these kinds of interchange refering to the possibility for soviet students to receive history emissions produced in Bulgaria and the access from Bulgaria "to the soviet accelerator in Serpuchov and Dubna through satellite communications" (p.17).

For these exchanges, international help and support for developing countries should be essential: in order to make feasible an educational software production that would be significant in quantity and quality following international patterns.

- - -

The equipment development and production proposes some problems related to the balance between national and international instances.

Not all countries have the conditions to produce the ground equipment required for the production, transmission and reception of educational communications. A very fast growth in the use of these equipments will weight, in developing countries, over the economical structures and the flow of capital and merchandises - considering that the developing countries are generally suppliers of raw materials and buyers of industrialized ones. Along with the ground equipment required, there will be also a need for film and video materials.

On the other hand, countries of increasing industrialization will certainly make some restrictions before an accelerated dissemination of equipment and materials to be received from highly industrialized countries. The question of defining what can be bought and what would result in the destruction of fragile productive capacities of an industrializing country will pass by unavoidable delicate international negociations. It will be perhaps the case of Brazil - exemplified by the current policy about informatics.

In the same time, research and training programs with international support may represent for these countries an amplifiation of their internal custom market for equipments and materials.

We shall consider here also the problem of equipment compatibility - which is a question of patterns to be negociated. The predictable tendence is a growing unification of patterns and simultaneous development of technolo-

gical resources for the adaptation from a system to another - which can be then integrated. I will not develop this point which is outside my field of experience.

From an educational point of view, the choice of kinds of equipment is crucial, refering to resources desired. In this sense, the document of Professor Meyerson is an interesting guide - and it sheds light on the question of educational options. Supposing that in the near future it will be possible to organize large systems of educational exchange, which options among the resources listed by Meyerson should be taken? And how to obtain, within a group of countries, similarity of options so as to make possible the exchange between all of them ? It is necessary to suppose that the implementing of equipment infrastructure must answer to requirements of educational communications internal to each country (for instance between its universities) as well as of international needs.

One last question about equipment is the professional qualifications required for its installation, operation and maintenance. Developing countries have frequently reduced conditions to guarantee these services - which may represent a hard restriction for the use of electronic technologies for education and research.

Meyerson relates technical problems of reception in the case of HIPAS-Lab (p.13 to 16), between Los Angeles (California) and Fairbanks (Alaska). If a simple difference of infrastructural conditions of two states of the same country appears as a limitation, we can predict the problems to be faced in a worlwide scale.

The possibility of sending international technicians may facilitate getting over theses problems. It is necessary, however, to protect the legitimate national interest of the countries which will receive that help - so as that, in the shortest term, they can qualify their own technicians and keep control over all parts of the telecommunications system which are established over their territory.

An additional question within that frame is the relationship among experts - considering that besides differences between lines of work there would be differences of culture, nationality and perhaps language.

[2.3]

No country today can maintain itself apart from international relationships. Even more, it is from international support and exchanges that a country may acquire some possibility of economic growth and better living for its population.

Those exchanges are intense and they present different flows - of raw material, of industrialized ones, of technology and know-how, of cultural products, persons, capital...

The meaning that can be assigned to these flows is not always positive for all participants of international concert. In some cases, the cooperation is the basis and the best consequence of international relationship; in other moments, a strong and rough competition prevails.

One can not believe that the specifically educational exchanges would be able to participate in that frame of interdependence and competition only with a positive sign. It would be undue optimism. I believe that, also here, the relations and exchanges shall be negotiated, and that each country has the right of defending its legitimate interests (without of course disown the others). The underdeveloped countries should find special support for that from international organizations and on a basis of mutual cooperation.

Those who are engaged with the objective of obtaining a better understanding between nations through educational changes should try, in each case, to study the question of the choices that the countries involved can make, between national interests and international engagements. The best balance between these alternatives will be put by different countries on different points. To balance these different balances is one of the challenges to be faced by international programs of higher education.

Serafimov says that "by 1990 the interuniversity center [in Bulgaria] will become a National Training and Information Controlling Center for the education in Bulgaria. It will be connected by ground-based communications lines with all Higher Institutions of the country and with other computer systems. The majority of the international relations of this center will be executed with satellites" (p.24).

Maybe the creation of international centers of that kind (with different structures following the country) would be the best basis for future international exchanges between universities and countries.

3. EDUCATIONAL USES OF ELECTRONIC MEANS

[3.1]

The possible uses are most varied. The "outline guide for users" by Meyerson is already an extended list of possibilities of image, sound, graphics, etc., retransmitted by telecommunications - and that list refers only to one of the forms for exchanging research and training services in higher education, the teleconference.

Serafimov summarizes (p.6) "the main technical possibilities of satellite retranslations for educational purposes".

Many other forms and processes shall be researched - not only to verify if they are feasible, but for examining if and how they are needed by potential users. And to verify their economical viability in the near future, and their greater or smaller facility to overcome national barriers.

Meyerson and Serafimov suggest the advantages of lectures made by outstanding professors. The simple lecture transmitted by television has relatively reduced production costs. The hypothesis of feed-back channels for debating may provide enriching possibilities for the students - but that may represent increasing costs not fitted for many universities and countries. I would suggest that, if at the receiving university there are no qualified professors for conducting the discussions themselves, the television feed-back system would be inefficient.

- - -

The communication of research - with demonstration of results, of problems surmounted, of methodological analysis - would be useful for the

dissemination of results and the spreading of benefits. Of course it is required that, at reception, these researches could meet similar concern and could be felt as relevant.

- - -

The retransmission of natural events and phenomena may represent good information for learning. Serafimov proposes that "instead of description of the El Nino or Tolbachik eruptions, the space techniques offer direct even in real time demonstration of these volcanoes" (p.36).

But the simple observation (direct or teletransmitted) of phenomena does not lead necessarily to learning. It is the role of university to analyse these phenomena, to examine their relationship with their context and to interpret them following the perspectives of one or other discipline.

- - -

All this proposes questions that require analysis: the question of motivations for the adoption of eletronic means; the question of adition against substitution as the main function to be assumed by educational communications; the question of synchronous transmission and use (real time) against storage; the question of planning and organizing reception, curricula, evaluation.

Certainly I cannot detail here these questions (among other possible and relevant ones) - since its analysis should be based on concrete situations. I will just make a summary reference to some issues that seem to be more evident.

[3.2]

I am not sure that electronic means would represent a neat immediate gain in learning efficiency (considering large operational systems).

After suggesting some stimulating possibilities of long distance TV or radio lessons, Serafimov proposes that "all this undoubtedly increases the interest to education, makes it easy to assimilate, agreable to accept, and the EFFICIENCY of the total education process augments together with its quality level" (p.36). The interest of the student, however, may not lie necessarily in the increased richness or stimulant characteristics of the mate-

rials presented. It is known that experimental situations are stimulating per se - and until now the uses of telecommunications for learning have been experimental ones. It is necessary to take in account the possibilities of Hawthorne effect. Besides that, young people are increasingly accustumed to plenty of images via television, and some characteristics which are taken today as stimulants soon may be felt as source of monotony.

Probably efficiency will always be (within any alternate means, electronics, books, TV or classroom) part of the relevance felt by the student in the material received, more than of external motivation.

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We are deeply accustomed to base educational structures of the main elements: printed materials and personal face-to-face interaction. Although much can still be developed in that field, it is clear that we know reasonably work out these two instruments of learning. Electronic means are still far from assuring the effectiveness already obtained by traditional means. Meyerson, in the conclusion of his text says that "the claim that telecommunication is as significant to education as the printing press may be excessive. We just believe it is the second most valuable technological innovation for learning" (p.82).

Maybe that secondary level of importance should be the best motivation for electronical insertions in university learning: in order to discover and develop their possibilities of renewal - more than to make learning immediately efficient.

I believe that personal face-to-face interaction is even more important than printed materials. Two levels of interaction are essential: interactions between professor and students; and interaction between students themselves, concerned by similar interest, dealing with the object of their learning. And here, electronic means may be particularly promising: because they can supply more than contents of good quality retransmitted from the best informative centers - they can offer new objects of concern, new challenges, new problems over which the students may perform their personal effort and new interactions within their groups of classmates. Serafimov underlines these stimulating possibilities of electronic means (item 4.1.4, p. 36, and item 1.5.4, p. 12).

[3.3]

Related to the previous point, we have the question of employing telecommunications "as an adjunct to [or as] a substitute for other kinds of human communication in higher education" - alternatives noted by Meyerson in the introduction of his paper.

The use of modern means in classroom where there exist already qualified professors involves only some adjustments related to the question of : training professors. We may suppose that they will be able to develop practices according to their objectives.

The substitution for lack of qualified professors seems to be less simple. Certainly, that possibility of substitution is one of the motivations for putting into practice educational telecommunications in developing countries. Amplifying the access to education by populations that have not yet high-level traditional school structures is an objective which can determinate the adoption of modern means.

I shall express here my scepticism as for that alternative - at least in the near future. We still know too few about controlling the pedagogical possibilities of these means. The probability of inadequate uses is too strong. And besides, if a country or region fights against poor school structures (buildings, equipment, materials, professors, programmes, organization skills,...) an important part of these elements should be provided precisely by the project of the technological system, along with the telecommunications program. Not only the costs would be too much elevated, but this would bring logistic problems and complex training needs. All that would have no guarantee of success - because the more fragile component of the system would be the human element, handicapped by the lack of qualified professionnals. Maybe in that case the best cost/effective alternative would be the improvement of the structures considered traditional (perhaps with some modern resources adequate to the local use).

In spite of the generous objective of amplifying rapidly the access to education, I believe that the option which proposes the best chances for international telecommunications will be, in the near future, to carry programs for cooperation of already well structured universities. From the experience acquired in the use of materials; and from new developments which should be made in this application field, it is probable that we could surpass the only additional use of educational software and develop complete programs

in the substitution line which would be effective.

[3.4]

Considering this additional use of modern means, which appears to me as the best option for higher education in the near future, we have another question which will require specific decisions in each project: the use of programs to be received and used in a simultaneous way (and real time); or the preference for storing materials. Meyerson refers to the alternatives of "synchronous" and "store-and-forward" conferences.

Certainly, always that a direct exchange is needed, the program should provide for time schedules and presence of all participants. I believe, however, that synchronous emission and reception uses are not necessarily the most important one - at least at initial phases of future national or international projects. That because of several reasons.

Time zone differences may put serious difficulties in the organization of schedules.

A daily regular sequence of programs for synchronous use would require perfect organization at all reception points - in which refers to time, to adequate equipment functioning and operation, to logistics... It would not always be guaranteed It is true that repeated programs in different times could be a palliative for reception problems.

On the other hand, besides reception, some time should be provided for following the use of transmitted materials. Complete learning is not obtained by the simple observation of educational programs - but through the capability of professors and students to work out the concepts, experiences and data received.

Modern possibilities of recording and storing (particularly by sound and video cassette) suggest that the most effective educational use of telecommunications perhaps will be associated to storing materials and using them following the convenience of local programs, curricula, conferences and research. This option will be more interesting at least when telecommunication materials should be additional to traditional structures and activities. Besides, that alternative seems to promise the greater impact over these structures and habits. The stored availability of outstanding information and data should modify the traditional shape of classroom activities (defined by an in-

formative relationship between professor and students).

Great number of students can receive good image and sound information (which can also promote interdisciplinary participation of several courses). After the reception, classroom meeting of professor and students (probably with reduced groups) can concentrate in working out the received information, in realizing experiments, in producing materials, and even in criticizing the programs.

The university libraries would be also stimulated to new practices. Besides the traditional and most important practices centered in books and periodicals, libraries would develop a main component for modern systems. The procedures associated to modern materials (storage, retrieval and use), very different of book-associated procedures, would have impact on library habits.

[3.5]

The question of planning and organizing reception, curricula and evaluation activities depends also on the decisions made about additional against substitutive uses of telecommunication.

Serafimov points out the difficulties "in establishing a feedback, and the testing of students progress", but he considers that "only a combined application will result in the rational use of the spaceborn advantages for educational purposes. In particular satellite emission accompanied by written material (including tests), video-records (for repetition of lectures and exercises) etc." (p.16).

It is possible that a certain number of international programs for higher education will adopt this global planning of the whole set of educational objectives, training procedures and evaluating activities for complete courses. I believe, however, that the preference for that alternative derives from traditional educational perspectives.

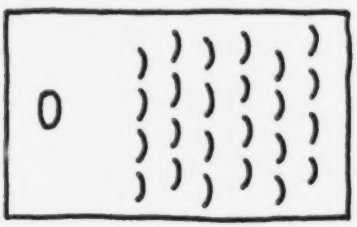
In a simplified way, we could distinguish, in the core of the teaching processes, two main elements: the information (existing knowledge available in society); and the working of that information by the student (through what he transforms himself - with the meaning of adapting himself to society, of acquiring what society disposes, but also with the meaning of reviewing, advancing, modifying, discovering new knowledge, viewing the world under new perspectives, criticizing, thinking). Traditionally, professors have the role of providing information (about which they should be experts) and the one of

stimulating the students to work out information (for which they should have pedagogical qualifications).

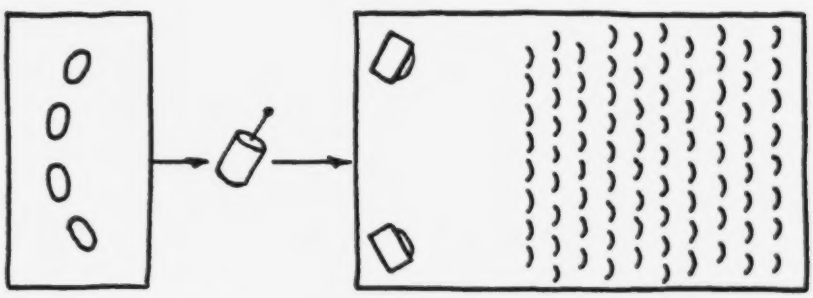
For accomplishing those complex tasks, the only existing help was the book. This way, the professor has been responsible for all aspects of the learning process - besides providing information and pedagogical stimulation, organizing, controlling, evaluating, supplying feed-back.

When modern resources are made available (visual, sound and electronic means in general), it seems to appear a tendency of replacing the traditional mean, the classroom, by a complex composite of new resources - but maintaining at the the extreme points of the teaching relationship (now separated by the set of communication means) professors (now in a work team) and students.

That kind of view could be represented as shown below.



direct
information and learning control
in traditional classroom



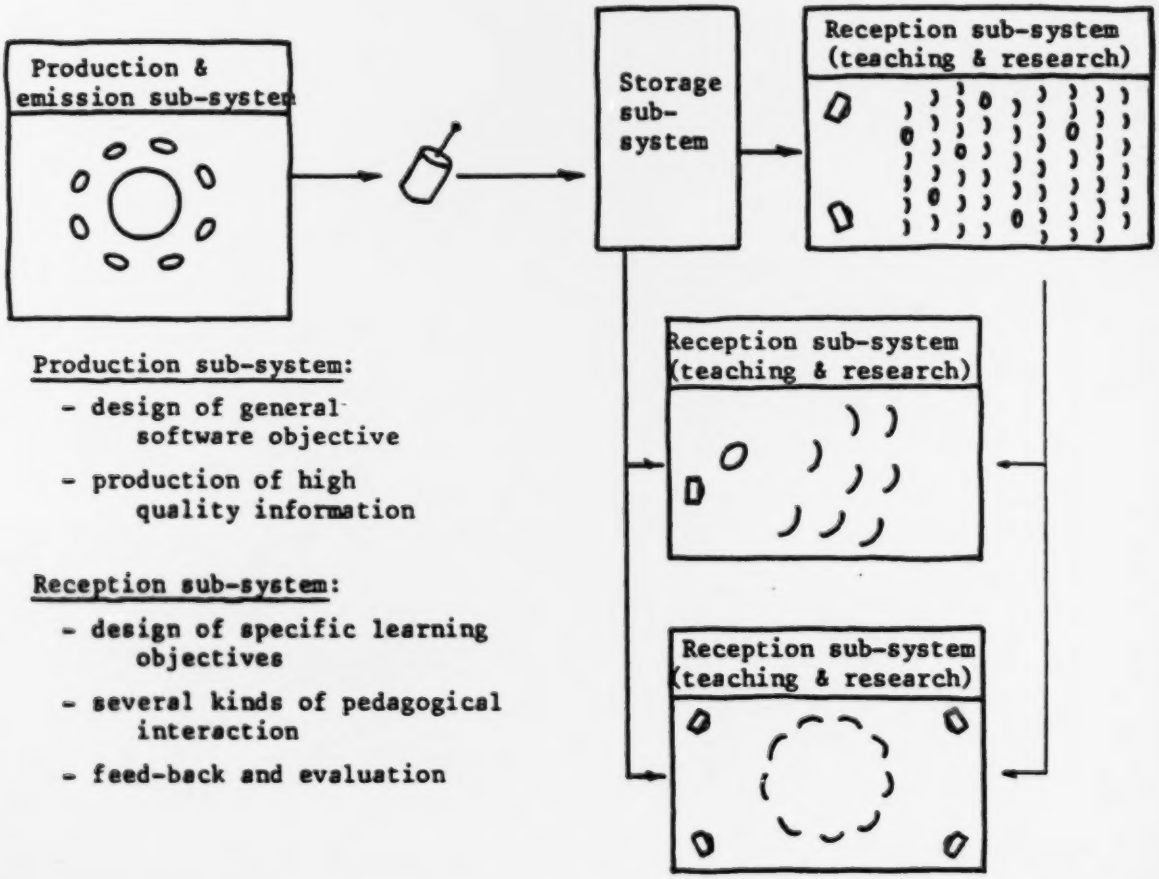
information and
learning control
via satellite

But here the basic relationship would remain "the same" - in the sense that all the aspects of the learning process would be controlled as a whole by the supplyer of information.

I think that other views, perhaps more fruitful , could be adopted. The inclusion of modern means may alleviate many informative tasks of

the professor; and should deeply modify his pedagogical work. It would be too much simple to assign all the former activities of the classroom professor to the organizing team of telecommunication courses. I think that the main task of this team is to provide information - that should be produced at the highest level of selection, structures and technical quality; and that should have the best pedagogical characteristics (in what refers to sequences, reasoning, demonstrations, raising of questions, etc.). But this material should not be seen as the only basis for the educational development of the student. It should be considered instead as an efficient object to be worked out by students and professors. Citing an experience in two-way channel between California and Ontario (p.6), Serafimov reports that the "students generally considered this satisfactory, though face-to-face access to lecture was more desirable".

This view would also mean that group organizing, controls, feedback and evaluation should be tasks to be executed by people at the reception end of the system (within universities, departements, etc.). This could be represented as shown below.


Production & emission sub-system
Storage sub-system
Reception sub-system (teaching & research)
Reception sub-system (teaching & research)
Reception sub-system (teaching & research)

Production sub-system:

- design of general software objective
- production of high quality information

Reception sub-system:

- design of specific learning objectives
- several kinds of pedagogical interaction
- feed-back and evaluation

This kind of alternative seems to be the more educationally sound; and also the more viable one, considering organization, logistic and cost aspects.

- - -

Other aspects of the question should of course be examined. If we surpass formal barriers of University (in which curricula, controls, certificates, are essential for the recognition of intellectual and professional graduation) new questions should be raised. The Open University, of Great Britain, is an important illustration of this other kind of considerations. Since the classroom walls are eliminated, when the student faces alone (or within groups) the educational software, organizational questions must be assigned to the telecommunications team. Of course the complexity of the production increases accordingly. Even in these cases, I think that the educational success will depend largely on the existence of socio-economical and cultural conditions in which the student (alone or within groups) will be able to organize and control his own learning - based on the transmitted materials but with great autonomy of decision about how to conduct his tasks.

[3.6]

In order to conclude this section, I would like to underline that I consider promising all the possibilities that should be based in the users' interest. More than supplying complete programs (with control and evaluation), the efforts of offering a greater variety of well prepared information seem to be positive. Within the options provided by a telecommunications system, the user (university, departement, professor or student) should be able to choose by himself what best fits his needs.

One of the positive aspects of computers networks for research and teaching is related to the fact that the user is the one who looks for the data required by his objectives. Naturally the building of the data system and the decision of what kind of data will be available depends on previous planning and on what each participant (university, country, international organization) will be disposed to supply.

- - -

As a last word in this section we shall consider the following. Universities provide not only professional skill but also (perhaps mainly) high-level cultural and intellectual capacities that are required for people to deal with their social, professional and life problems, in a very global way. Without neglecting graduation in professional skills and the global education within the limits of the higher education institutions, maybe some of that cultural/intellectual stimulation could be spread over the University limits (as today's perception of this kind of institution) for all the population who have access to a TV or radio set (and probably in the near future, a computer terminal). Even without being related to professional qualification, cultural and intellectual stimulation would result in important impact of high level education on the groups involved. This impact would revert to the universities under the form of better prepared and motivated new students, and of new expectations about higher education.

Serafimov refers to that "knowledge dissemination among young people" and he says that "extra-class education benefits significantly from TV-programs in the Eastern Europe countries and USSR". "Similar is the situation in the dissemination of cultural information and [...] lectures in history and theory of art..." (p.21).

Of course, in order to work out these possibilities of educational tlecommunications, the availability of satellites and associated communication systems is not enough. It is necessary to have educational software produced and stored; and most of all, to have implemented conditions for routine and continued production. Some aspects and problems related to the production of educational materials are considered in the next section.

4. THE PRODUCTION OF EDUCATIONAL MATERIALS (SOFTWARE)

(4.1)

The production of educational materials to be retransmitted by by telecommunications presents itself differently from the other kinds of human communication that originate via satellite or other large systems of diffusion.

In the news information, in business, in the commercial/cultural production, in the personal phone communications, the creation of messages is made "spontaneously" in the interest of the participants of emission and reception. Diffusion systems were being created according to the needs and the asking for increasing speed, geographical range and number of messages.

In some cases, the producers of the messages expanded their possibilities of distribution and diffusion; in other cases, technological systems were built and put at their disposal (through participation in the investment required and maintenance costs, etc...) to answer a significant increase in the range of distance or in the number of people reached. Already there is intense production or an interest already established in generating messages.

This is the case, for instance, regarding the news, where the use of satellite permits its diffusion (image, sound, text) which would be produced anyway for local or national distribution (by TV, radio and newspapers).

In a similar way, business communication refers to decisions and data which were already sent by mail and telegraph. It is obvious that, there was the possibility of efficient transmission to long distance by fast mans, new uses were developed, new possiblilities of production and exchange

appeared, and the telecommunication systems grew more and more efficient.

This has not happened with educational communication. One of the reasons for that situation may be due to the kind of messages traditionally produced in education - lectures and books. Another motive could be the fact that the universities, from one point of view, are closed systems which suffice for themselves and assemble in relatively concentrated areas all the materials, buildings, equipments required, and in the same time their users, professors and students. The reception of an outstanding professor from another university, for instance, even if it is frequent, represents a very small part of the teaching supplied in higher educational institutions.

It is interesting, however, to note that the possibility of immediate and generalized acess to outstanding professors (wherever they might be) is indicated by Serafimov and Meyerson as an important use of telecommunications. According to current perspectives, it does not seem to sufficiently motivate the implementing of telecommunication systems - although, within a future system already implemented, that could come to be an important use of it.

On the other hand, with regard to publications, the interchange systems between libraries seems to answer the more evident problems of obtaining materials not immediately available in the university.

- - -

Some kind of information currently produced in the universities could be directly retransmitted by telecommunications - films, photos, sound records, computerized data. It lacks, however, motivation for making available that information; and it lacks organized knowledge, accessible to potential users, about what could be available and what could be asked (except under the traditional form of divulged publications).

Another limitation would be the question of knowing if the existing information would be sufficient (or could be produced in a sufficiently fast flow) in order to justify the implementing of operational systems which would surpass the scale of experimental programs and would become regular and routine ones. A related question refers to the number of users - if they could assure a regular flow of demand.

In the absence of telecommunications demand by more or less spontaneous processes, the university researchers and professors, who believe in the probable benefits of the modern means for education, are led to propose great systems in which all aspects of the educational process would be taken

into account: the distribution of information, its production and the organization of its use.

The document of Noguchi and Nemoto emphasizes that "it is very important to chalk out a plan envisaging a worldwide educational system which may be utilized by all peoples" (p.6). And, in the conclusion of their section 4 (p.14) it appears that "when considered on a worldwide basis there is no viable alternative to the satellite system in the construction of a global information network".

Of the three systems for application of satellite technology in education discussed by Serafimov (p. 13 to 18), two of them consider very elaborate structures, mainly oriented to providing feed-back and centralized control of the flow of information.

(4.2)

Assuming the implementing of a telecommunication system for a given region of the planet (possibly including the use of satellites), one of the first questions to be posed, related to the educational production, should be if the material (software) would be produced by a main production center or if it would be scattered among several universities and/or small production suppliers (and, in that case, what participation from the central satellite systems would need definition).

The centralized production poses some difficult problems about what to produce and about its adequation to the users' needs; besides that, it implicates high levels of concentrated investment. On the other hand, it would guarantee a certain correlation between the transmission possibilities of the system and the availability of materials for distribution.

A scattered production could be more intense and diversified, generating more programs according to the number of involved institutions; and it would have its costs distributed so as to obtain more easily the participation for the investments to be done (mainly if we consider that the produced materials could be directly used within the university which produces them). Besides that, differences of productivity from one point to another would not harm the global program - which would mean a smaller risk as compared with centralized production.

An eventual difficulty would be ensuring the compatibility of materials for general distribution. That could be one of the aspects where

the participation of the distribution system would be required - for defining the needed patterns.

If a large scale system, responsible for all aspects of the educational process, is adopted, a main worry of its planners should be to obtain a high level of efficiency. The control over all phases, from production to reception and use of materials would have to be intense. In the same time the risks and costs would be perhaps excessive.

I have the impression that the implementing of such a system would find insurmountable problems in the near future. Some points that I considered in the first section (between national and international instances) and in the second one (about educational uses) result in that view. It is in the level of production that my position finds the strongest arguments.

We should decide which educational means and products depend essentially on large-scale transmission (via satellite) and which means and products are also adequate to a small scale use (those that would find in telecommunications just a good possibility for quantitative diffusion).

A great number of uses cited by Serafimov and by Meyerson are possible through video-cassette recordings, movie projections, slide projections, sound recordings, microcomputers. Other educational uses will depend widely on "space communication": group meetings over great distances; immediate feed-back for TV-lectures; exchange of data during the execution of research jointly conducted by several universities... And many other possibilities will certainly be developed after building and operating distribution systems by satellite.

The question which seems initially relevant, more than "what can be made utilizing an educational satellite", would be "what can be made, with modern means, without utilizing a satellite". A good answer to this question would help to find the best ways for arriving, in the future, at an effective use of educational satellites.

[4.3]

There follows a prospective view of a possible sequence of steps which would lead from an initial emphasis on small and disseminated programs to extended uses of telecommunications including specialized educational satellites.

a) Stimulation of small scale university production of modern materials for education. The main use of that production (video-cassette tapes, printed materials, sound records, data collections, etc.) would be made within the university that produces it - or eventually by exchange between university that produces it - or eventually by exchange between universities of the same geographical area. The international participation at this level would be limited basically to the specification of some patterns and to help some universities to create a production capacity (mainly training people and helping with equipment).

b) Stimulation of an exchange system on a larger scale - following the type of exchanges between libraries. The exchanges would occur mainly under the form of hard materials (effective change of copies of video and sound cassettes, computer disks, etc.). Eventually, following telecommunications conditions, ground TV, radio diffusion and phone lines would exist.

This step would not only enrich the files of universities, but would also stimulate the habit of (and the demand for) modern video, sound, electronic resources. This would prepare users - professors and students - for later development.

Serafimov refers to this kind of exchange, already made by regional satellite as a distribution device: "One of the first satellite lines was established between Sofia and Moscow for transmission of scientific information. This line connects the computer center of the Soviet and Bulgarian Centers for Scientific and Technical Information. Thus the transmission of bibliographic, patent and other information was largely intensified and updated" (p. 23).

Of course, if satellite lines are available, they are useful - but distribution by ground retransmission and even by mail (depending on the quanities involved) is possible.

In this phase, the main role of international organizations would be to stimulate accords between universities of the participant countries, and to facilitate the access to communication channels.

c) On the basis of stored materials and of production systems already implemented, a certain use of satellites would be feasible. Part-time use of communication satellites would be established, and exchange routines between universities would be developed.

Now, new uses and products would be possible to develop - e.g. two

way communications and synchronous lectures.

Serafimov refers to the Moskva ground-based station, employed for "educational and other missions as well as for the bilateral transport of scientific, economic, commercial and other data" (p. 22). He remarks that "INTERSPUTNKI system channels not sufficiently charged are used during the night time" for "standard transfer of memorized data" (p. 23). In section 4.3.3. (p. 38) he reports that "despite the fact that Arabsat is mainly oriented towards commercial telecommunications, it is considered by this organization that future satellites from this system may house partially educational programmes for primary and secondary schools".

The cost of part-time use of communications satellite would be shared among users, with eventual participation by international organizations. Each university would be able to obtain materials produced by the other ones on an exchange basis. This would avoid the need to pay for programs; also it would stimulate production to be made available to the system. Similar exchange processes are already employed, via satellite, for news information at the international level.

d) As the educational exchanges between universities would become increasingly regular and routine, the natural tendency would be to develop new uses and new needs. This would lead to requests for amplified spans of time use and for coverage range.

The international organizations would have here two main roles: the research and development of new uses, techniques and pedagogical methodologies; and the stimulation of large programs which would benefit several countries.

e) Thus, assuming that new habits of using telecommunications would be already established, it is probable that a need for specifically educational satellites would be felt.

Serafimov states that "educational programs and the transport of research data have their specifics and require for satellite with particular construction, payload and possibilities. This of course may be combined to satisfy other (for example communication) needs" (p. 31).

The tested, used and stored materials at universities should be sufficient, at this time, to feed satellite transmissions. The number of users would be able to guarantee the economical support to the telecommunications

part of the system. Most of all, the capacity of new and continued production would be already installed - it could require amplifiations but not implementing from zero point.

Another thing to be considered is that the educational use of modern means, already operational then, will have provided important knowledge about vital characteristics of an educational satellite and its distribution system. The planning of these elements will be then facilitated, with smaller risks.

The planning, the required accords between countries and the implementing of an educational satellite system will depend largely on the participation and support of international organizations.

f) After that, we can only imagine that new uses would very probably be developed. I believe that the broad retransmission of educational information, as much as point-to-point information, can have an important impact on higher education. If telecommunications can approximate and help integrating university efforts (increasing their efficiency and diversifying their goals), they can also help reduce barriers between the University and Society. The question of access to higher education will ask for new views, different from today's dominant ones - which are largely marked by a classroom-oriented definition of the University.

The Open University, in Great Britain, is a well known experience in that field.

Serafimov reports that "a TV University was established in China in order to raise the cultural and scientific level of population" (p.6). He says also that "the most positive results were obtained in the USSR with extramural students (continuing their normal work as the respective feed-back system by correspondence was provided" (p.7).

[4.4]

The above perception about the possibilities of implementing a telecommunications system for education through several steps may seem excessively prudent. Indeed, it takes in account the most serious problems for the operation of large systems: the production of materials.

That production poses problems at the following levels:

- the high costs;

- the question of deciding what to produce, considering that from indefinite needs which can be raised, only a small part of it will receive financial support and human resources to be developed;

- the question of deciding who should produce the educational software, with which perspectives;

- the question of the users' preference for one or other kind of transmissions and of specific materials.

A step by step building of a future educational telecommunication system promises the best answers to those questions:

- the costs would be shared on the basis of participation of countries and universities, and would be low in the initial steps;

- the flexibility about what to produce would be sufficient - as each segment of the future system would produce for its own;

- similarly, the cultural and national differences would be safeguarded;

- finally, the users would have the last word in the choice of what interests them, and about the best moment to use it.

Once implemented, the educational telecommunication system would not impose its structure as a ruler over the university, but instead it would function simply as a "mechanism for the delivery of substance", following the view of Meyerson in the conclusion of his paper.

At the same time, it would produce the best of its impact: an opening towards new experiences, with new educational dimensions, based on concrete needs which will be then perceived by its users.

5. CONCLUSIONS

The preference, in my paper, for some aspects of the general question - satellite technology and higher education - led me to focus some of the items treated by the three base-documents and to leave aside other ones. I hope, nevertheless, that the points discussed can adequately complement those three documents and result in a useful comment on the perspectives proposed by them.

I would like to refer, within these conclusions, to some other points that are not specifically considered in the main part of my paper. Most of these point are covered by Serafimov's document - which is the one which more directly treats the items listed by IAU/UNESCO Joint Committee: present situation; current plans; relationship between experts and users of educational telecommunications; potential uses and potential impact during coming decades.

[5.1]

I suggested (in section 4) that the most important question to approach today would be the development of educational software production capacity - by universities and other institutions. That does not exclude at all, in my opinion, the renewal of satellite experiences such as those cited by Meyerson and by Serafimov. Of course these two kinds of activities would be mutually stimulating.

[5.2]

I did not discuss the specific case of computers networks. I agree with Meyerson (p.38 on) about the advantages of computer conferencing and about the need for computers networks for higher education and research. I believe that the possibilities offered by computers are responsible for the current renewal of interest in educational telecommunications.

The enthusiasm about satellite applications in education within the sixties (and early seventies in Brazil) resulted in TV programs Today, it is the computer that re-opens the question - certainly renewing the interest the other modern means.

[5.3]

The possibilities of interaction between educational and mass communications production should be studied.

Serafimov refers to the interest for scientific popular films (p.9) and to the "role of the universities in the dissemination of cultural knowledge" (p.10).

Some kinds of cultural entertainment and of news and documentary information currently broadcasted by commercial and popular TV stations could represent a starting point for the development of production which would have interest for higher education. Let us consider the popular programs with simplified treatment of events, natural phenomena, historic themes, concepts, theories, social problems, etc. At the opposite end, let us consider highly sophisticated programs treating scientific, technological, cultural and historic concepts, to be used only by university researchers and students. Between these extremes, I do not think there exists a neat frontier separating what is "popular" from what is specifically "at university level". Instead, there would be a gradual variation of alternatives. Some of them would be able to create a bridge between university and society in a shared interest for the reception.

I believe also that the gathering of university specialist knowledge and mass communications professional experience would be useful to produce those kinds of materials and bridge the two sides of university walls.

[5.4]

I agree with Serafimov's perspective about the "space technology transfer to education and the reverse process - from its progress back to the acceleration of the space activities" (p.11). For that reason, it is not enough to make experiments at the level of telecommunications. A new university, computer-oriented and audio-visual stimulated, would require in time the need for larger access and for interaction with other universities. That would produce as well an impact on telecommunications.

[5.5]

Serafimov verified, through contact with researchers in several countries that "practically no projects exist concerning satellite use into university education and research" (p.27).

I think that the interest aroused by the possibilities of using TV and satellites for education, since the sixties, led mainly to projects concerning elementary and secondary level education. The educational problems of developing countries are more urgent at those levels. Besides, those are the levels where we find, obviously, the greater number of students who are potential users of TV and radio lessons. At least, these were the main reasons that led Project SACI, in Brazil, to choose elementary level as its main target.

Today, the development of computer technology and the perception that the benefits of telecommunications do not refer only to increasing quantities may lead to new interest in projects, in the near future, directly aimed at university teaching and research.

[5.6]

The section 3.1 of Serafimov's document deals with the "necessity for establishment of new space methodology and pedagogics for teaching in universities and other levels of educational programs" (p.28). He lists, in eleven points, some really important needs. I think that some of them reinforce my views about the main problems to be dealt with - those are the first seven